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THE USES OF ALGEBRA IN STUDY AND READING.[1]

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I. THE USES OF ALGEBRA AS SHOWN BY AN INVENTORY OF HIGH SCHOOL TEXTBOOKS.

As a crude but impartial method of estimating which algebraic abilities are useful and how great the need for them is, we have examined from two to four high-school textbooks under each of the titles of Table 1, noting the nature and extent of each demand or opportunity for the use of algebraic processes.

The books examined were as follows:

Robinson and Breasted: History of Europe, 1914.
Hazen: Modern European History, 1919.
Beard and Bagley: History of the American People, 1920.
Muzzey: American History, Revised Edition, 1921.
Ely and Wicker: Elementary Principles of Economics (Revised), 1917.
Marshall and Lyon: Our Economic Organization, 1921.
Giles: Vocational Civics, 1919.
Hart: Community Organization, 1920.
Hughes: Community Civics, 1917.
Hodgdon: Elementary General Science, 1918.
Barber, Fuller, Pricer, Adams: First Course in General Science, 1916.
Snyder: Every Day Science with Projects, 1919.
Salisbury: Physiography; Briefer Course, 1919.
Wright: Manual in Physical Geography, 1906.
Peabody and Hunt: Elementary Biology, 1912.
Gruenberg: Elementary Biology, 1919.
Hodge and Dawson: Civic Biology, 1918.
Hegner: Practical Zoology, 1915.
Packard: Zoology, 1904.
Allen and Gilbert: Botany, 1917.
Bergen and Caldwell: Introduction to Botany, 1914.
Jackson and Daugherty: Agriculture, 1908.
Warren: Elements of Agriculture, 1909.
Conn: Elementary Physiology and Hygiene, 1910.
Fitz: Physiology and Hygiene, 1908.
Calkins: First Book in Psychology, 1910.
Pillsbury: Essentials of Psychology, 1920.
Kalenberg and Hart: Chemistry, 1913.
Brownlee, Fuller, Hancock, Sohon, Whitsett: Elementary Principles of Chemistry, 1921.

[1]This investigation was made possible by a grant from the Commonwealth Fund.

McPherson and Henderson: First Course in Chemistry, 1915.
Henderson and Woodhull: Elements of Physics, 1900.
Carhart and Shute: Physics, 1920.
Millikan and Gale: Practical Physics (Pyle's Revision), 1920.
Matteson and Newlands: Foods and Cookery, 1916.
Greer: Textbook of Cooking, 1915.
Greer: School and Home Cooking, 1920.
Kinne and Cooley: Foods and Household Management, 1914.
Kinne and Cooley: Shelter & Clothing, 1913.
Baldt: Clothing for Women, 1916.
Matthews: Sewing and Textiles, 1921.
Cooley and Spohr: Household Arts for Home and School, 1920.
Stilwell: School Print Shop, 1919.
Matthewson: Notes for Mechanical Drawing, 1904.
Griffith: The Essentials of Woodworking, 1908.

TABLE 1.

Subject	Total Number Linear Inches Examined	Total Number Linear Inches Using Algebra	Per cent Linear Inches Using Algebra	Number Separate Times Algebra Was Used	Average Number Uses of Algebra Per hundred In.	(4)
Social Sciences						
American History	7,070	210	3.0	56	0.8	
Community Civics	4,010	6	0.1	4	0.1	
Economics	5,220	146	2.8	38	0.7	
European History	8,200	48	0.6	11	0.1	
Total: Social Sciences	24,500	410	1.7	109	0.4	
Physical and Biological Sciences						
Agriculture	4,690	30	0.6	10	0.2	
Biology	5,200	154	3.0	44	0.8	
Botany	3,990	6	0.2	1	0.03	
Chemistry	7,540	161	2.1	424	5.6	(1)
		332	4.4	6,079	80.5	
Total Chemistry		499	6.5	6,503	86.1	
General Science	10,440	304	2.9	111	1.1	
Physics	7,550	307	4.0	837	11.0	(2)
		4	.1	132	2.8	
Total Physics		311	4.1	969	12.8	
Physiography	4,290	513	12.0	127	3.0	
Physiology	3,730	10	0.3	5	0.1	
Psychology	4,410	23	0.5	8	0.2	
Zoology	4,330	6	0.1	2	0.05	
Total: Physical and Biological Sciences	56,170	1,856	3.3	7,780	13.8	
		1,520	2.7	1,559	2.8	(3)
Practical Arts						
Cookery	8,920	89	1.0	47	0.5	
Mechanical Drawing	340	8	2.4	141	41.5	
Sewing	7,680	1	.01	1	0.01	
Woodworking	1,029	0	0.0	0	0.0	
Total: Practical Arts	17,960	98	.5	189	1.1	
Total for all subjects	98,630	2,364	2.4	8,078	8.2	
		2,028	2.1	1,857	1.9	(3)

The amount of text examined in each subject, the frequency of the uses of algebra, and the total use of algebra are reported in Table 1.

The units of measure—"an inch examined," "an inch of algebra used," and "a use"—are, of course, extremely crude, but entirely impartial.

1. In Chemistry 332 inches, 6,079 separate uses, are chemical formulae and reaction equations, each writing of either being counted.
2. In Physics 4 inches, 132 separate uses, are chemical formula and reaction equations, each writing of either being counted.
3. This line gives the data with the chemical formulae and reaction equations discarded.
4. In the ordinary high school text 100 inches is approximately eighteen pages.

A detailed study was made of the kind of algebra called for under the five following heads:

(1) Manipulation of complicated polynominals;
(2) Formation and solution of identities and equations;
(3) Formation and evaluation of formulae;
(4) Development and use of the notion of function;
(5) Construction and interpretation of graphs for
  (a) statistics
  (b) functions.

Table No. 2 presents the facts as found.

The following conclusions from a survey of these tables would appear to be justifiable:

(1) Omitting from consideration courses in mathematics itself, there is no need in high school studies for facility in complex manipulation of polynomials.

(2) In present textbooks there is no use made of the mathematical concept of function.

(3) Except in chemistry and physics and agriculture the study of equations has at present no utilization in high school work.

(4) The making of formulae is practically not required of the high school student.

(5) The comprehension and evaluation of formulae is required only in physics, chemistry, and in the physical and chemical parts of general science.

(6) The mathematical graph, either as illustration of the scope of the formula, or as vivifying the concept of function, practically does not occur in any high school work.[1]

(7) The statistical graph is used to a greater or less degree in all high school subjects investigated, the number of linear inches given to graphs (in cuts and explanations) being twice as great as for all other types of the utilization of algebra combined.

It is important to note to what extent the algebra of which use is made is necessary to a comprehension of the texts considered.

To read a statistical graph is within the power of the high school student untrained in algebra. Pictograms and cartograms have become part of the common language of newspapers and magazines. But to make them offers such difficulty that

[1]Its only utilization in high school physics lies in the reading and construction of graphs illustrating the resolution of forces.

only the exceptionally gifted child might be expected to master it without specific instruction. Still less would one anticipate that a critical attitude concerning the veracity of a graph and ability to detect falseness and graphic misstatement would develop without drill in that precise function.

TABLE 2.

	Manipulation of Symbols		Equations: Identities		Equations: Conditions		Formulae: Formation		Formulae: Evaluation		Function		Graphs: Statistical		Graphs: Mathematical	
	Inches	Occurrences	Inches	Occurrences	Inches	Occurrences	Inches	Occurrences	Inches	Occurrences	Inches	Occurrences	Inches	Occurrences	Inches	Occurrences
European History													48	11		
American History													210	56		
Economics													146	38		
Civics													6	4		
General Science									13	4			287	107		
Physiography													513	127		
Biology													144	44		
Zoology													6	2		
Botany													6	1		
Agriculture					6	1							24	9		
Physiology													10	5		
Psychology													23	8		
Chemistry			235	906	124	276	1	38	132	5281			7	2		
Physics					240	570			63	254					4	13
Cookery					3	5							27	6		
Sewing													1	1		
Wood Work																
Mechanical Drawing									8	141						

In chemistry the formula is not the equivalent of the formula in algebra. To quote from a recent text (Brownlee, Fuller, Hancock, Sohon, Whitset, "Elementary Principles of Chemistry," pp. 114, 115, 123) "The formula of a molecule is formed by grouping together the symbols of the atoms composing it.

. . . When a molecule contains more than one atom of the same kind the symbol is not usually repeated, but the number of atoms is written as a subscript to the symbol. . . . The only thing that decides the formula of a compound is a chemical analysis. The symbol of an element and the formula of a compound represent more than the name. The symbol of an element stands for one atom of that element . . . and for a definite quantity of the substance" (by weight).

Further, in the chemistry texts reviewed the chemical reaction identities in the two newer books are written with arrows, while in the older one the sign of equality is used. For example, the identity written $NaCl+H_2SO_4 = Na\ H\ SO_4+HCl$ in the older books, in the newer is written $NaCl+H_2SO_4 \rightarrow Na\ H\ SO_4+HCl$. The student is instructed to read such an equation "NaCL and H_2SO_4 will yield $NaH\ SO_4$ and HCl." If the reaction is reversible two arrows are used thus: $2NH_3 \rightleftarrows N_2+3H_2$.

To quote again from the same source (p. 133): "These equations are not like mathematical equations. They are brief statements of experimental facts and should not be written unless it is known that the reactions actually take place. If we know by experiment:

(1) That the substances do react;
(2) The composition of each of these substances;
(3) All the products formed;
(4) The composition of each product;

we can represent the reaction by an equation, and calculate the relative quantities involved."

The treatment of formulae and equations in algebra may then do as much harm as good to the student's learning of chemistry, especially if "emphasis" is put on the equation of condition rather than on the equation of identity.

It is, therefore, only in the "problems" of the chemistry text that the student would find his elementary algebra of advantage. The equations, which will be made, are, in the large fraction of cases, of the form of a proportion in which three terms are known numerical quantities. A child thoroughly grounded in proportion in arithmetic would be able to make and solve most of these without recourse to algebra, though the student who has had equation drill in algebra might fairly be expected to form and to solve such proportions with increased readiness and smaller percentage of error.

A similar conclusion regarding the equation problems of agriculture is legitimate. The problems deal chiefly with balanced

rations and are similar to the algebra problems of alloy or mixture. A knowledge of the proportion equation suffices for the solution.

In high school physics the significant demand for algebra lies in the reading and evaluation of formulae. Typical formulae are:
$P_1/P_2 = D_1/D_2$; $S = 1/2gt_2$; $I = E/(Re+Ri/n)$; $V = \sqrt{2as}$; $E = R/N$; $(P_1V_1)/(P_2V_2) = T_1/T_2$.

These formulae are selected from those stated in Millikan and Gale, Practical Physics, (Pyle's Revision); 1920; pp. 36, 76, 77, 109, 137, 280.

To read these and such other formulae as the student will probably encounter in high school physics requires knowledge of the signs +, −, = ; the fraction line, the algebraic expression of multiplication, the use of subscripts and exponents,[2] the radical sign and the parenthesis, in addition to the fundamental notion of the expression of quantity by letters as well as by digits.

The student well prepared in arithmetic probably knows all of these except the expression of multiplication, and the subscript and literal notations, before he studies algebra.

It would be only just, however, to expect that one who had studied algebra would bring to these formulae a richness of content and a clarity and certainty of meaning that should make his comprehension of what he reads in them more vivid.

The evaluation of such formulae from an algebraic point of view means the substitution (in an algebraic expression) of numerical values for the various literal quantities and the performing of the indicated operations. The answer sought will require no more than addition, subtraction, multiplication, division, squaring, and square root, in various combinations. These do not demand mastery of algebra, but it is likely that the student of algebra would be spared the labor and ignominy of certain errors in the manipulation of his quantities.

For instance, in $S = 1/2\ gt^2$ the student unacquainted with algebra is in danger of multiplying the values of g and t, dividing by 2, and squaring the result, or of multiplying, squaring, and then dividing. Any teacher made familiar with like errors by their continual recurrence could supply equivalent illustrations. A very small amount of properly learned algebra would free the student from such practices.

Further, the student unacquainted with algebra would find

himself quite at a loss in the derivation of new formulae from those given.

To illustrate, by the algebra student $S = 1/2\,gt^2$ is transformed into $g = 2s/t^2$ or $t = \sqrt{2s/g}$ with a small amount of labor, but to the uninitiated each new form is a totally new experience. He can neither make it for himself nor readily understand how it was obtained by the other student. The foundation formula acquired through reasoning or experimentation is thus deprived of the richness of application legitimately to be expected from it.

In high school physics as in chemistry a large number of problems is given in the texts examined. These problems present almost exclusively data to be dealt with by means of formulae found in the body of the text. The student must select the formula appropriate to the problem, make the needed substitutions, and solve the resulting equation.

The complexity of the operations required in such solutions rarely goes beyond the clearing of fractions in a proportion, transposing, combining terms, and extracting a numerical square-root.

The following formulae present from the algebraic point of view the maximum of difficulty:

[8]$1/p+1/q = 1/f$ with numerical quantities given for p and q, to solve for f;

$K = (l_2-l_1)/l_1\,(t_2-t_1)$, with K, l_1, l_2, t_1, known, to solve for t_2;

$I = E/(r+r^1)$ I, E, r, being known, to solve for r^1;

$I = nE/(r+nr^1)$ I, E, r, r^1 given, to solve for n;

$f = mv^2/r$ f, m, r, being known, to solve for v;

$t = \pi\sqrt{l/g}$ t and l being given, to solve for g.

The algebra required in these is certainly much less than that ordinarily taught in the first year course.

To recapitulate: I. As a preparation for high school subjects outside the mathematics courses as they are at present taught, so far as may be judged from textbooks, the most extensive need for algebra is in the reading of statistical graphs, and to a far lesser degree, in the making of them.

II. As a preparation for physics the chief value lies in the mastery of the formula, particularly in handling the transformation known as "changing the subject of the formula." The stu-

[7]It is useful for the student to understand both positive and negative exponents for the expression of standard numbers, though rarely beyond 6, and the fractional exponent 1/2, and, rarely, 1/3 and 1/4 as an alternative for the use of the radical sign.

[8]From Carhart & Chute: Practical Physics; 1920, pp. 254, 290, 383, 384, 134, 139.

dent unacquainted with algebra is entirely at a loss in proceeding with this type of work.[4]

III. The solution of physics problems demands the ability to choose the appropriate formula, to make substitutions, and to solve the resulting equations. This involves skill in clearing of fractions (chiefly in proportions), transposing, combining and taking numerical square root.

IV. For the solution of chemistry problems, the ability to form a correct proportion is of high value. The algebra problems which can be applied with advantage in this field are those dealing with proportions, mixtures and alloys.

The next question that presents itself is: Can algebra be utilized by other high school subjects to greater degree than at present with profit to these subjects, and with reinforced vitality in the algebra itself?

Let is be assumed for convenience of classification that possible utilization of algebra may occur under the same five heads already noted:

(1) Manipulation of Complicated polynomials;
(2) Formation and solution of equations;
(3) Formation and evaluation of formulae;
(4) Development and use of the mathematical concept of function;
(5) Construction, interpretation and criticism of graphs—both statistical and functional.

In no subject of the high school curriculum outside the mathematics courses is any need for the manipulation of complicated polynomials discovered, nor does any such need seem probable.

By the formation and solution of equations certain science courses might be much enriched. However, the need would seem to be for extreme facility in the handling of easy equations rather than the formation and solution of complicated ones. Especially is this true of the ordinary proportion equation. Charles' Law, Boyle's Law, the laws of the five simple machines (usually given in first-year general science as well as in physics and chemistry) changing recipes in cooking; adjusting patterns in sewing; obtaining lengths for use in mechanical drawing, or in scientific free-hand drawing; plan-making and model-making in wood and metal work and other shop work; all these demand ready use of the proportion.

A pseudo-use of the identity occurs in such dictionary and word-analysis forms as "biology = bios, life+logos, study of."[5] It is probable that such a form more readily conveys its meaning

[4]Nunn: The Teaching of Algebra, 1914, p. 78, also pp. 14, 15.

to the child who has studied algebra than "Biology is derived from two words 'bios' and 'logos' meaning 'life' and 'study of'," while if fifty such derived words are to be taught the advantage of symbolism from the mere consideration of space required for printing is patent. The identity in chemistry already has been exploited. Reaction away from the algebraic identity is the present trend.

This form of work readily passes over into the formation and evaluation of formulae. It seems certain that added usefulness could be found in certain subjects were the child equipped to make a formula, or to use one when given. Differing minds, to grasp and retain with ease, require differing forms. In cookery it might be profitable to the student if he were required to transform rules into equivalent formulae. For instance, the length of time necessary to cook a roast of beef—"a quarter of an hour to the pound and twenty minutes extra"—or the amount of coffee to be used—"a spoonful for each cup and a spoonful for the pot"—are doubtless more easily remembered if presented in formula as well as in rule. Formulae for balanced rations, for infant feeding, for the use of leavening agents, might profitably occur. A move in this direction is the present custom of writing recipes by presenting first a table of the ingredients and their amounts, then a paragraph describing the method of combining them. The advantage here is the advantage of all algebraic symbolism, such compactness as to make possible a complete survey of the "elements of the problem" with a minimum expenditure of time and thought.

In sewing, formulae on the allowance of goods for the making of ruffles, for accordion and other kinds of plaiting, length of the bias strip for goods of given width, are devices for storing needed facts in the memory in an economical form. The allowance of embroidery threads to cover certain spaces are usually made nowadays by the experienced intuition of the worker or the sales woman, with consequent over or under supply. Perhaps in time formulae for them will be developed that will prove of advantage.

In hysiography it would be of interest and profit to present such formulae as $d = 1.22\sqrt{h}$, where h = the height of the observer above sea level and d the greatest distance at which an object on the sea is visible to him.

The utilization of the statistical or pictorial graph has already

Certain texts use this form "biology, bios = life + logos = study of," a form distinctly reprehensible from the algebra teacher's viewpoint.

been general in all high school subjects. What is needed is the development of the critical faculty in reading and in evaluating such graphs. Especially is this true of the pictograms which utilize natural three-dimension forms. In determining lengths for proportional facts due regard should be paid to formulae for surface, volume and perspective. The student needs to be taught to avoid the false inferences which are natural when a pictogram naturally interpreted in units of volume is presented in linear units.

Many subjects would find it advantageous if they could utilize the mathematical graph, that is, the graphic presentation of a law or a function. It is the aim of science to formulate its conclusions not as mere statistics but as mathematical laws. But at present expressing such laws for the student in a mathematical form is rarely done. Whether this is because the student has not been qualified by his study of algebra to grasp such statement, so that the vernacular must be used instead, or because the writers of the texts are unable to put their conclusions in such form, is not pertinent to the present discussion.

Practically the only use of this highly refined tool of exposition discovered in our textbook survey is to be found in Ely & Wicker's Elementary Principles of Economics (revised edition, 1917, pp. 183-201).

Certainly, many of the laws of economic dependency, certain basic notions of continuity and sequence and causation in history; facts of growth versus soil conditions and the composition of soils in agriculture; laws of growth increases in botany; interdependence of animal and plant life in biology; time and rate in interest, and cost-price relations in commercial work; all these might be made clearer to the student by correct and appropriate use of the mathematical graph.

The advantage of such graphic representation to supplement data by interpolation and extrapolation probably needs no emphasis with high-school students, the rather a caution against reading unfounded conclusions into graphs is needed. The fallacy of coordinates, the dangers inherent in optical delusions, the misunderstanding occasioned by the omission of zero reference points, should be pointed out. Also, warning is needed against over-use. It would be easy in such work to go beyond the point of diminishing returns for high school students who are little equipped for scientific generalization, but a small

amount of such work might be made a source of illumination and progress.

For most high school students any larger use of the function concept than that suggested in the mathematical graph is of doubtful value. It is one of those fundamentally powerful conceptions whose elaboration has been one of the half dozen significant achievements of the race, but to the high school student it is vague and tantalizing and stimulating rather than clarifying. To sum up:

(1) Involved manipulation of polynomial expressions is not a justifiable way of using the high school student's time.*

(2) Since the application of equations in other high school subjects is chiefly in the proportion form, mastery of that form and other easy equation forms should be secured.

(3) It would be profitable to extend the field of application of the construction of formulae as well as their evaluation.

(4) There is need for the careful development of the art of criticism as applied to graphs.

(5) The presentation of laws by means of mathematical graphs should be encouraged.

(6) The function concept should be used when advantageous, but with economy.

*This statement is meant to cover addition and subtraction of long expressions; multiplication and division of polynomials; manipulation of fractions with polynomial terms; squares and cube root of polynomials resulting in answers of more than two terms; involved factorization of polynomials; reduction of radicals (or fractional exponents) whose index is greater than three; operations with polynomials containing radicals; the factor and remainder theorems; and the binomial theorem, when the exponent is larger than five.

(To be continued)

MANGANESE IN 1921.

The domestic shipments of high-grade manganese ore—containing 35 per cent or more metallic manganese—amounted to about 13,000 gross tons in 1921, of which more than 10,000 tons were shipped from Montana, according to H. A. C. Jenison, of the United States Geological Survey, Department of the Interior. The shipments of ore containing 10 to 35 per cent of manganese amounted to about 72,000 tons, most of which was shipped from Minnesota. The shipments of manganiferous and ferruginous manganese ore amounted to about 14,000 tons.

The net imports for the first eleven months of the year amounted to 386,405 tons of high-grade ore and oxide, valued at $3,288,595. Of this Brazil contributed 247,568 tons, valued at $7.58 per ton, and India 113,730 tons, valued at $6.46 per ton.

The most important event that may affect the future of the domestic industry was a favorable report by the House of Representatives on a proposed tariff on imports of manganese ore of 1 cent per pound of metallic manganese content of ore or of concentrates containing more than 30 per cent of metallic manganese. The measure has not been reported on by the Senate committee.

GEOGRAPHY AND SOCIALIZATION.[1]

By Wm. Wade Walters,
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In an article by H. G. Wells printed in the *Post-Dispatch* on Wednesday, November 16, I found the following discussion of fundamental differences in education and citizenship in Japan from what we find in England and America.

"Some weeks ago I had a very illuminating talk in my garden at home with two Japanese visitors, Mr. Mashiko and Mr. Negushi, who had come to discuss various educational ideas with me, And they told me things that seem to me to be fundamentally important in this question. 'We build up our children,' said Mr. Mashiko, 'upon a diametrically different plan from yours. We turn them the other way round. Obedience and devotion are our leading thoughts. All our sentiment, all our stories and poetry, the traditions of centuries, teach loyalty, blind, unquestioning loyalty of wife to husband, of man to his lord, of everyone to the monarch. The loyalty is religious. So far as political and social questions go, it is fundamental. But your training cultivates independence, free thought, unsparing criticism of superiors, institutions, relationships. Perhaps it is better—and more invigorating: but it seems to us wild and dangerous. We begin to have a sort of public opinion, but it is still diffident and timid.'

"An American or an Englishman, he said, cared for his country, because he believed it belonged to him; a Japanese cared for his country because he believed he belonged to it. One could not pass from one habit of mind to the other, he thought, without grave risks and dangers. It is easier to destroy obedience than to create responsibility."

Statesmen, philosophers and educators are thinking and talking, in these early days of the new era, of education as of fundamental importance in national and international affairs. Acquisition of skill in reading, writing, spelling and arithmetic is no longer considered sufficient preparation for citizenship. The quotation from Mr. Mashiko, of Japan, shows that the nation that would maintain an autocratic government must look well to the way it "builds up" its children "upon a diametrically different plan" from that of a nation which sets its face toward a progressive democracy seeking an ever-increasing welfare of all the people through the cooperative effort of most of the people.

The progressive democracy seeking the welfare of all must "build up its children" with habits of clear purposeful thinking and the will to attack and overcome difficulties, with habits of intelligent self-restraint, and self-direction and perseverance in the execution of a purpose, with habits of individual responsibility and the cooperative sharing of responsibility with the social or industrial group, and to rightful leadership. They must be "built up" in the spirit of sympathy and fair play and coopera-

[1]Read before the Geography Section, C. A. S. and M. T., Soldan High School, St. Louis, November 25, 1921.

tion, with ability to play the part of leader in thought or action when occasion requires or opportunity offers.

They must be built up with a desire to do and the habit of doing with an exaltation of the idea of social service and the habit of rendering service to others on their own initiative, with a feeling of ownership and participation in all that is social.

The citizen built up by an efficient educational system for participation in a progressive democracy is a very different personality from the automatic iron man, Percy, who performs impossible tasks when his master pushes the button, and from Jack London's unsocialized "Sea-Wolf," a man of superhuman strength and intelligence, but utterly incapable of citizenship in any state.

The day of unrestricted individuality, even among the richest and most powerful, is rapidly passing. Not for long will reactionary Japan be able to "build up her children" into automatic citizenship loyal to an irresponsible government.

Political democracy is in the ascendency now, and social and industrial democracy are following in her footsteps.

The building up of our children into strong, efficient, socialized personalities is of very great importance to every community, city and state in these United States.

What is geography? We all agree that geography pertains to the surface of the earth, both land and water, and the soils and minerals found on and under the surface. We would agree that geography includes the air and the light and heat from the sun in so far as they affect the surface of the earth in its relations to the welfare and satisfactions of man.

Geography deals, also, with man and his occupation of the surface of the earth and the changes he makes upon the surface of the earth. Geography includes a thin layer of the surface of land and water. In small areas it extends down to the depths of mines and wells and up to include the skyscrapers of our cities.

Most elementary school courses include three to four years' work in geography, with children from nine to thirteen years of age. What geography should we teach in the elementary school to these boys and girls?

If we look at any of the standard geographies in use in the public schools during the last twenty years we find a superabundance of subjects. They all contain a brief treatise on the astronomy of the solar system. The meteorology of storms and

atmospheric pressure and regions of calms and trade winds and the general movements of the air are given to the little ones in approved scientific form. Our geographies include astronomy, meteorology, physical geography, biology. They include agricultural, commercial, industrial, political, social, religious, and historical geography.

A new light appears upon the horizon, a hope for the teacher of geography in the elementary school. I refer to the idea of human geography.

The most notable contribution to the comparatively new human geography is a book of that name published in France in 1911 and a translation in America in 1920, by Rand McNally. The author is Jean Bruhnes, Prof. of Human Geography, College of France. He treats the subject from a scientific, not at all from an educational, point of view. He is a scientific geographer and his book is written for scientists and for advanced students in universities. But while Bruhnes has had no thought, apparently, as to the educational uses of geography in elementary and high schools, he has, in his masterful attempt to simplify and circumscribe the work of scientific geographers, led the way toward more rational and useful geography texts and courses of study for educational purposes in the schools.

Bruhnes includes man and the surface of the earth as he finds them acting and reacting upon one another, each changing the other but neither complete in its mastery. This field of physical and human action and reaction he divides into three essential elements, or divisions, as follows:

I. Unproductive occupation of the surface of the earth.
   1. Buildings of all kinds including fences, barns, sheds, dwellings, and public places.
   2. Roads including streets, highways and all railroads and their right of way.

II. Productive use of biological species.
   1. Cultivation and improvement of useful plants.
   2. Conquest and improvement of useful animals.

III. Destructive exploitation.
   1. Devastation of useful plants and animals.
   2. Exploitation of soils and useful minerals.

He holds that all the social sciences need this science of human geography and can use to advantage the truths worked out by scientists in the sphere of human geography, but the earth sciences and social sciences, as such, should not be included in the science of Geography. He would confine the science of geography to six groups of facts, two under each of the three main divisions.

It is the business of teachers of geography in elementary schools, high schools and teachers' colleges, and of principals and superintendents of schools to select geographic material best adapted for purposes of education.

Education is the growth, development, and desirable modification of personality. Experience, real and imaginary, is the only means of education. Self-activity is the only means of development, growth and modification of character. Physical and human environment may stimulate self-activity; conversations and literature and the beauties of art and nature may inspire thoughts and emotions. But it is the thinking and feeling of the pupil that produce attitude and action and develop personality.

What kind of self-activity, of real or vividly imagined experience, tends to socialize the individual?

Many of the activities of pupils can be measured as to skill and tested as to ability. But the best and most fundamental elements of character and personality cannot be adequately tested or measured. Insight, tact, disposition, initiative, responsibility, and many other fundamentals of personality are the immeasurables and imponderables in education.

The process of education for socialization must be based upon human social instincts. Interest in others and their experiences is a social instinct. Sympathy with the emotions of others, with joy and sorrow, pain and pleasure, success and failure is an element of socialization. The spirit of fairness, the desire to help, to cooperate, to lead, to share, to communicate, to serve, to please are all social instincts.

Instincts are generally recognized as fundamental in the education of animals. No one would think of offering the same schooling to seals and elephants, eagles and geese, horses and dogs. The education of animals is accomplished through their own conduct modified by playing one strong inherited instinct against another, plus the use of whatever intelligence the animal possesses.

The instincts of man are much more numerous than those of any of the lower animals and they are much more easily modified by educational agencies. They are not fixed and determinate as are the instincts of the ant, the bee, and the wasp. They can be educated, and should be nurtured and utilized at the right time. Prof. James says: "To detect the moment of instinctive readiness is the first duty of every educator." Prof. John

MacCune, in *The Making of Character*, says that this statement by James "finds confirmation alike in the fullness of the life in which no strong and healthy instinct has looked in vain for timely nurture, and in the forlorn spectacle of those whom we sometimes see struggling belatedly in maturer years to cultivate pursuits or pastimes for which the auspicious educational hour has long passed."

Halleck in his interesting little book on *The Central Nervous System*, bases a similar conclusion upon the exercise of the brain. He says, "A person who might have been ordinarily successful in the walks of life may be a nonentity because his latent capacities were not developed at the proper time. It is always too late to be what you might have been."

If the educator would use geography as a socializing agency in the education of the child, he must carefully select material and adopt his methods with reference to the instinctive development, the experience and intelligence of the child. Geography, Book II, and standard school histories used in the grades are almost—I will say quite—uniformly much better adapted to the senior year of the senior high school or the freshman year at college than to the sixth, seventh and eighth grades in elementary and junior high schools.

To any one fairly familiar with a considerable number of the buildings used for various purposes in different parts of the world, with the streets of Cairo, Venice, London, Peking, New York and Washington, with canals, railroads, Roman highways of Europe built more than two thousand years ago or with travel in the Missouri Ozarks or Southern Illinois, no argument is necessary to prove that a study of the two phases of the unproductive occupation of the soil may arouse, through real and imaginative experience, great interest in people all over the world. Knowledge of the cultivation and use of the 300 out of a total of 150,000 plants that are extensively cultivated for use, and of the two hundred species of animals used by man in all parts of the world will tend to promote the mutual friendly interest of distant peoples. Stories of devastation of useful animals and plants and the exploitation of coal and other minerals all over the world appeal to a very strong human instinct, of even young children in the fourth to the sixth grades, the instinct of sympathy in misfortune, especially when the misfortune is mutual.

And always these geography facts should be studied as elements of man's relations to the surface of the earth, and the

climate and the air and the waters; and to the mysterious influence of these things upon man and the way man uses these things to his advantage, and changes them sometimes purposely for his own good and sometimes carelessly to his serious harm. Geography should be taught as "a subject filled with action and emotion but based squarely upon that immeasurably ancient physical geography which gives the final reason for and the final limit to—everything."

Anyone who has traveled, even moderately in his own country, and learned something of geography through real experience, who has associated with people living in decidedly different physical environments will agree that it broadens our sympathies and changes our attitudes. Reading regularly any good geographic magazine has, through vividly imaginative experience, a similar effect.

Geography and socialization is a three-fold subject by implication. All three phases have been introduced. The field of geographic material has been narrowed so as not to be confused with zoology, botany, agriculture, geology, physiography, commerce, economics, sociology, history, political science, religion, anthropology or astronomy. All science and all philosophy make contributions to the science of geography. Geography in turn is needed in all earth and all human sciences. But the modern geographer recognizes his definite fields of research, and the educator has a chart and compass to guide him in selecting geography material for educational purposes.

We have contrasted the thoroughly socialized citizen of a progressive democarcy with children purposely built up to serve the purposes of an autocratic state. We have shown the socialized citizen to be very different from the extreme individualistic type of predatory highwayman, buccaneer or profiteer. Everyone in America agrees that our public school systems should produce well developed socialized citizens. It is agreed that the science of man's relations to his physical environment, and the effect of the conditions of the surface of the earth upon him, with his adaptations and reactions, is rich in educational material for socializing the schools.

Scientists will readily agree that education is a dynamic process, that all education is the product of self-activity, physical, mental or emotional, always a real combination of these three activities with one of them emphasized, that real conscious experience must be the basis of all educational activity, that the pro-

cess may be assisted by vividly imagined physical experiences in which the mental and emotional elements are quite real.

We will all agree that the aim of education, through educational activities based upon fundamental human instincts used at the proper time, is the growth, development and desirable modification of personality.

The problem is pretty well solved for college students and for those engaged in research work in the science of geography. But the great problem of what to select for use in elementary and secondary schools, and when selected for each stage of development how best to use it has not been solved. Paths have been blazed and our objectives are becoming clearer. Some notable contributions have been made. I will speak now of one of the greatest of those contributions.

In 1917 during our participation in the great world war, J. Russell Smith, of Columbia University, author of *Industrial and Commercial Geography, Commerce and Industry*, and *The World's Food Resources*, became convinced that a textbook in geography was one the means by which we could best get ideas and attitudes established in the minds of children that would result in a better socialization of the next generation. With this ideal in mind he set to work on a two-book series for the elementary schools.

Book I of Dr. Smith's *Human Geography* contains 360 pages and 502 maps and illustrations. I have seen this book in use in the fourth, fifth and sixth grades of a school in which the work of the elementary teacher is specialized to practically the same extent as in high schools, where one room is devoted exclusively to geography material and geography work, where material from the public library and from other outside sources has been used extensively for years, where cooperative projects are undertaken, where "Cooperative Management" is the most popular slogan and the keynote to the conduct of the school, a democratized and socialized elementary school where the ideal of *Human Geography* (Book I) is understood and appreciated. The pupils of the fourth, fifth and sixth grades find this book intensely interesting and they are able to easily understand and appreciate pictures, maps and the text. They enjoy the solution of the problems and the carrying out of the exercises suggested at the close of each chapter. They use these for discussion and competitive exercises in their graded teams of seven or eight pupils per team.

The two geography teachers, the only geography teachers in a school of twenty-eight teachers, consider Smith's *Human Geography*, Book I, a great improvement over any book they know for a basic text in the grades. It is a geography in accord with modern standards. It is not a treatise on economics and the industries. It is not a collection of selections from meteorology, astronomy, physiography, geology and other social and natural sciences. It is a story of people and places on the earth, and the story utilizes the experiences and appeals to the imagination of children. The pictures are adapted to the appreciation and stimulation of children. They arouse eager desires for new experiences. The maps are clear and not overloaded.

This little book is the best guide I have found for the selection and treatment of geographical material adapted to the grades.

I am not ready to speak very positively because my experience has not yet been corroborated by many thoughtful educators, but I believe this little *Human Geography*, Book I, published by the John C. Winston Co., contains all that is needed in a basic text on geography below the high school. We treat botany, zoology, chemistry, physics and other sciences very simply in the grades. Why should the grades attempt senior high school and junior college work in geography and history?

When we remove from the grades those skills, experiences, and bodies of knowledge that are adapted very much better to the basic instinctive development, the experiences and the grade of intelligence of youth beyond the adolescent stage in high school and college; then the elementary curriculum will be no longer crowded. When higher education takes over what properly belongs to it, we can allow the children under fifteen years of age to be real children in school as well as at home and when unsupervised everywhere. Then we can have time to encourage childish projects and the solution of real childish problems. Then we will learn to live as naturally in school as in a well regulated home. When we bring into the elementary shcool only such activity, skills and knowledges as the children need most and enjoy most we will find that children delight in socialized activities, and in knowledges that tend to establish ideas and attitudes promoting socialization and tending to develop citizens adapted to a progressive democracy. The rationalized public school is a factory where citizens are in the making rather than a place where children are attempting to leap the chasm of adolescence and youth and attain in childhood those knowledges and attitudes suited only to adults.

THE TEACHER SUPPLY IN SCIENCE SUBJECTS.

By Herbert Brownell,
University of Nebraska, Lincoln.

Lovers of the writings of Ian Maclaren will recall Domsie's ambition ever to have a student from the Glen in attendance upon the University at Edinboro. Of him it could be said that "Seven ministers, four school-masters, four doctors, one professor" had been sent out from the little school in Drumtochty.[1] He was always on the lookout for a "Lad o' pairts" to win "honors" for the Glen.

So, likewise, it would be well if science departments of colleges and universities were ever seeking young men and women of superior worth and fitness as regards character and scholastic attainments, *and who give evidence of teaching aptitude.* Upon such students when found, now one here and now one there, might well be urged the opportunities, the personal advantages, and the social and public service possible during several years devoted to teaching in public schools. Though a small number only of prospective teachers be furnished in any one year from any one department, the total would become no inconsiderable number when gathered together from the half dozen or more departments of college sciences represented in the curricula of secondary schools. To the preparation of such students in the subject matter of science, preferably always of a somewhat extensive rather than intensive type, there should be added the preparation for teaching involved in suitable methods and practice courses provided in teacher-training institutions. This done, and the problem of a continuous supply of properly trained teachers of high school science, especially for the smaller high schools, would remain no longer hopeless, and might perchance entirely disappear.

It is suicidal for colleges and universities not to give sustained and well-directed efforts towards keeping a teaching force in the public schools suitably fitted both in scholarship and by training to render teaching service of highest efficiency. Nowhere is this more true than in connection with the sciences. From these high schools comes almost exclusively the collegiate student body. In these high schools generation by generation are taught and trained leaders in citizenship upon whose enlightenment and appreciation of scientific achievement very largely depends mastery of those agencies which make for civilization and for industrial prosperity.

[1]*Beside the Bonnie Briar Bush*, by Ian Maclaren.

In elementary schools discussions of the facts of life surroundings, and interpretations of these facts in terms of life interests, characterize largely the educational procedure. The chief end to be attained for the children in these schools is enlargement of vision and increase in mental capacity. In college and university, on the other hand, knowledge already classified is presented for study purposes. The immediate end in view is a mastery of knowledge in its organized form as it has been chosen from certain selected fields of human learning. In the science studies such mastery becomes possible within the limited times given to school courses by reason only of an acceptance of the generalizations constituting the laws and theories of science.

The high school science teacher occupies that educationally ill-defined zone of transition from the characteristic teaching processes of the elementary school to those of the college. The teaching problems in the high school are grave ones, arising in part as they do from conditions over which the teacher has no control. There is an insistent demand from the colleges for a better preparation of high school graduates, a more intensive and exact knowledge of the branches studied. There is a woeful lack on the part of pupils entering the high school of definiteness in knowledge, and of any suitable training for acquiring it in the fields of natural science. Pupils commonly come into the high school habituated to the use of textbooks as an original and final authority. Development of any "scientific attitude" within the time available for science studies, and a reawakening within the children of normal desires for comprehending changes occurring on every hand about them in the natural world, becomes almost hopeless. Such problems centering in the work of the high school science teacher, difficult as they must ever be and unlikely of any complete final solution, demand that none but specially trained and suitably qualified teachers shall give instruction in the various branches of science, and in the various stages of science teaching.

It is well to keep in mind here, too, that it has been well said[2] that the great teacher is one of great personality in whom nobility means more than attainments, one whose personal touch upon students is sure to be quickening and ennobling. While he must know the subject he is teaching, he must know even more profoundly and sympathetically the object he is teaching, namely, his pupils for whom he is guide and leader. The greatest students of the world have been formed one by one by great masters.

2 ;Professor Andrew F. West: Princeton Ed. Rev., June, 1907.

It has come to be a belief of the writer based upon many years of inspection of fitness of candidates in training for teaching high school sciences that natural aptitude for making a successful science teacher is more readily and assuredly noted in pupils taking science subjects in high schools than it is in the later college courses. Upon teachers of high school science rests in no small degree a responsibility for the guidance and inspiration of those from among whom the needs for science teachers in the smaller high schools later shall be met. There is need of men and women as teachers of science subjects in high schools as well as in colleges who have the spirit in them that was in "Domsie."

An unceasing round of change in the personnel of the rank and file of the teaching forces of the country at large is an outstanding condition affecting the public schools. So far as concerns the "science teachers" in the smaller high schools this is markedly true. Then, too, no injustice will be done the apt high school student who is guided into making suitable preparation for devoting a few years of his life to science teaching. Aside from other considerations there is in the time so spent an "education" more worth while, possibly, than the same time spent in advanced college courses. There is the added incentive of service rendered society over and above what is represented in one's pay-check, and a recognition of obligation to society for the educational advantages offered free to each generation of boys and girls.

Differences in opinion there may always be as to what constitutes suitable preparation for the exceedingly difficult situation confronting the teacher of "science" in small high schools. Some few there are who require little if any special training to attain proficiency in teaching beyond what comes by reason of experience. Very generally Teachers Colleges have come to their own slowly and not without much of tribulation. But the time is long o'er-due when frank recognition shall be made of a responsibility resting on science teachers in secondary schools and in colleges to promote the interests which center in science instruction in the public schools by joining hands with teacher-training institutions to the extent at least of directing to them young men and women of "pairts" fitted by nature and purpose as well as in knowledge to become suitable guides and counselors of youth in the ways of science.

ABSTRACT REASONING AND AUTHORITY VS. COMMON SENSE IN SCIENCE TEACHING.

By Fred. D. Barber,
Illinois State Normal University, Normal, Illinois.

The weather records will show that the week, January 22-January 28, 1922, was a good, cold week. Zero weather prevailed throughout Illinois. Nevertheless, the writer received the following letter from the principal of a school in Green County. The letter was dated January 24, 1922.

"Prof. Barber,
"Normal, Illinois.

"Dear Sir:

"Please be so kind as to write me which will freeze the quicker, hot or cold water. I am unable to find anything in reference to this in any of my physics textbooks.

"Thanking you, I am

"Yours truly,

"______________________

"Principal.

"P. S. The problem I have in mind is this: If a pan containing boiling water is placed in a room 10 degrees below 0, and another pan containing water at a temperature of 40 degrees Fahr., is placed in the room at the same time, which will freeze the quicker?"

In reply the suggestion was made that since the termperature was near zero authoritative statement relative to the above question might possibly be dispensed with; that abstract reasoning might also be dispensed with; that it would be possible to arrive at a conclusion by placing two similar vessels, one containing hot water and the other cold water north of his school building and observing results.

When, if ever, will the time come when our teachers of science will apply common sense to their work? Undoubtedly it is all too common practice for teachers of science to rely implicitly upon the authority of the textbook. Common-place, homely, everyday science questions are not often directly answered in our science textbooks. The teacher who attempts to teach science and who has never been trained to study and analyze the science situations of common, everyday life but who has been led to memorize only brief historic sketches and multitudinous abstracted principles will in all probability fail to comprehend

and understand the common, daily-met applications of science to the affairs of daily life.

In the writer's judgment our textbooks in science, or perhaps it would be better to say physics, the writer's special field, generally fail decidedly to put the student into that attitude of mind which will lead him to consider in a commonsense and rational manner the everyday applications of science. Is it not true that our textbooks in physics, taken as a whole, may properly be characterized as compilations of stereotyped and abstracted laws and principles, together with a few hundred or thousand mathematical problems chosen especially to illustrate and involve the laws and principles taught? Who can successfully defend the average physics textbook as an adequate exposition of physical laws as they are found applied in the usual daily activities of life?

The above quoted letter may be considered by some as an extreme example of a failure to apply in a rational manner the facts and truths taught in the physics class. Are we fully justified in such a conclusion when we know that the writer of the letter has so far made good that he has become the principal of a school in a rather small but progressive community? Moreover it is the positive knowledge of the writer that this same question, once raised, was argued pro and con by fairly mature teachers who had enjoyed the privilege of having studied physics in the high school.

It is the writer's opinion that if the day comes when our science teaching is generally planned and organized for the express purpose of leading our young people to comprehend and control their environment instead of learning an abstract, scientifically and logically arranged catalogue of scientific facts we shall then turn out high school graduates who will not fall helplessly before an application of science.

The uneducated person, or rather the person who has never been trained to rely upon authority and upon the application of half-assimilated scientific principles, would hardly hesitate to give a correct answer to the opening question of this paper. Common sense and the common observations of life will usually not lead such a person far astray. The writer heard a middle-aged man who has completed a high school course in physics and has taught for several years contend that the hot water would freeze first. Asked for an explanation, he proclaimed that: First, the heat so separated the molecules of water that the cold

penetrated it, or the heat escaped from it, more rapidly than was the case with the cold water, and second, the evaporation was more rapid from the hot water than from the cold water and that evaporation means the carrying away of heat from the body.

It is my contention that science may be so taught, and I fear is too often so taught, that the learner is little benefited when he goes forth butting up against the actual affairs of modern life. My contention is that, if science courses were organized primarily for the purpose of examining into and understanding the applications of science on every hand in every day life, the results would be much more satisfactory and profitable. To cite a few historical facts, develop as demonstration or laboratory problem a certain principle, abstractly state that principle and finally require the solution of a few mathematical problems involving it, does not in my opinion guarantee that the student will recognize and fully comprehend the situation when he is face to face with an application of that principle set naturally into the common, everyday affairs of life. On the other hand, if his knowledge of science were gained by studying primarily his environment, seeking its explanation and control, noting the scientific principle involved here and there, is it not probable that his mental activities would be decidedly different throughout life?

General science, as a whole, has, it seems to me, pointed out the proper method of attack in science teaching, in the upper grades and largely so in the high school. A psychological and not a stilted logical organization of science in our public schools seems to me desirable. The texts would probably be somewhat more voluminous, and probably somewhat less mathematical, so far as the physical sciences are concerned. It also seems clear that no important principle need be omitted. If a scientific principle is not to be found in one's environment can it properly be called important in one's education? The psychological organization of science materials is destined, I believe, to succeed the logical organization of science materials. In the place of training in abstract reasoning and the memorizing of authoritative statements as the content of a science course, it is my belief that the time will soon come when the primary purpose of the course will be to analyze and understand one's environment.

THE CHEMISTRY EXHIBIT AS A PROJECT REVIEW.

William F. Einbecker,
Highland Park, Ill.

Change in Science Teaching.

During the last six or seven years, there has been a big advance in educational methods in high school science. This advance was inevitable; education is a process of evolution, and educators must obey the laws of life, changing their methods as experience and environment direct. The change has come in science teaching with the introduction of the project method. It is not my purpose to discuss in detail the project method as applied to chemistry. I merely wish to offer to you a few ideas which I believe have made my teaching better than it would otherwise have been. Discussions centered upon the advisability of introducing the project method into our teaching have done much to remedy glaring faults in our methods in the past, and I believe they will do so at present. A year or two ago, we were all so enthusiastic about the project that we were in danger of forgetting that there were other methods that had a place in the educational process.

Faults in Present System.

Laboratory work in chemistry must of necessity take a prominent place in the program if our students are to make any practical use of their study or are to remember what they have studied for any considerable length of time. Perhaps the memorizing of textbook information and the emphasis on textbook work cannot be avoided as long as our present system of examinations exists. At present there is no adequate way of examining students in laboratory work when they enter college, take civil service examinations, or apply for a position. Have you never felt that many parts of your texts were too abstract, too technical in their terminology to be understood easily by your pupils? Yet your students are compelled to memorize this material because both you and your students are judged by the amount of this textbook material that is memorized. Perhaps these faults can be remedied by improving our textbooks. However, in the meantime, most teachers cannot write their own texts and must use what is available. For the average high school teacher there is one other course open, and that is to improve the laboratory work.

Laboratory Work and the Project.

I think most of us realize that the laboratory work is the vital part of our course, whether we give it that place or not. The world is full of living, useful, and interesting materials which students will study if given the proper encouragement and help. The textbook is after all only the textbook and not chemistry. The question in our minds then is, usually, not, "Shall I teach laboratory work?" but "How shall I teach it?" Laboratory work in biology, physics, and other sciences has been greatly improved by the introduction of projects. Undoubtedly there is a place in chemistry for "a plan of action, which, when carried to completion, results in something accomplished." In the short time that I have been teaching, I have endeavored to find this place for the project method.

Another Change in Teaching.

Before I discuss the place of the project, I want to call your attention to another change in the method of teaching chemistry. During the past two years we have been hearing much of the annual exhibit of the work done by the students. The science show has done much to motivate the work of many teachers. In my teaching I have tried to combine both the annual exhibit and the project method, and I believe this to be an excellent combination.

Contrast in Methods.

The Usual Method.

In the usual method of teaching laboratory work, the student is given a manual, some materials, his textbook, and a few reference books. He is told to go to work, being left more or less to himself, asking questions of his instructor or referring to his books from time to time. His laboratory work is separate from his recitations, and both of these are separated from the lecture work. If the work is coordinated the text usually receives the emphasis. The great advantages of this method are: The teacher can divide his time evenly; the class can cover a large amount of written work; and the pupils can make a good "showing" in examinations.

The Project Method.

In the project method, the materials may be the same, and the same work may be accomplished, but the emphasis is entirely different. The instructor endeavors to lead the student into some difficulty. The student is then led to make out a

plan of action which, when carried out, will solve his problem. In the project method of teaching a course in chemistry, the first step is to collect a large number of materials, finding out, as often as possible, the composition and behavior of each. Then we may determine how each is prepared and how it is used. In studying these materials the question eventually arises, "What is the length, breadth, volume, or density of this sample?" or "How is it affected by light, heat, or electricity?" The student can be made to realize that he must know how to make certain measurements before he can continue his study systematically. After the study of physical measurements, the effect of physical forces on different substances, mixtures, and solutions may be observed. In this way the entire subject of general chemistry may be developed. The great advantage of this method is that the student is taught to think for himself a large part of the time. He must gather information and data, classify facts, reason, and draw his own conclusions. The disadvantages are that there are no textbooks on the market that are complete and depend upon this method; the teacher must work day and night preparing outlines of work for his class, or

neglect about half of it; furthermore, students cannot discover all the fundamental laws for themselves; and finally, much information that could be memorized or secured in some other way advantageously must be neglected because of the large amount of time devoted to the principal topics.

The Importance of Review.

Laboratory experiments are too often just laboratory experiments. We make little or no use of the principles of review, and yet we expect our pupils to remember reactions, laws, and formulae. The "Chemistry Exhibit" gives an excellent opportunity for reviewing the work of the year. In the work which I am about to outline, I have endeavored to combine the usual laboratory method with the project method and have used the annual exhibit to develop the review.

The First Semester's Work.

During the first semester, I have done very little work involving the project method, outside of making collections of various materials commonly used such as soap, lye, baking powder, salt, washing soda, etc.; and the study of the behavior

of these substances in our homes. I have centered the work about the essentials, air, water, salt, and substances related to these. However, if a student asked a question which I thought he could have solved for himself, I put him to work on it. For instance, much may be done towards answering such questions as, "How does heat affect metals such as lead, copper, iron, and mercury?" "Does glass melt?" "Why does Ivory Soap float?" and "Does hydrogen come from the acid, water, or metal when prepared by the interaction of a metal and dilute acid?" Other problems similar to the last of these arise with almost every experiment. There is almost always some point in the experiment that is told to the student instead of being verified. These points offer an opportunity for introduction to a project. The separation of the so-called solvent of liquid shoe blackening is an interesting sidelight on distillation. The action of litharge on hydrochloric acid forms an interesting problem on the preparation of chlorine by oxidizing agents. Frequently the introduction of a project that gives negative results is valuable in keeping the class in a truly observant state. The heating of sand to secure oxygen is a case in point. Of course, the study and preparation of common materials is one that is available to the project method as well as to others.

The Second Semester's Work.

During the second semester, I centered the work on the chemical industries. An increasing number of projects similar to those already mentioned were given. Collections of products and raw materials give the class an excellent opportunity to become familiar with the world's work. The testing of foodstuffs, as milk, meat, and flour are exceedingly practical projects for girls. In the preparations for our exhibit, the project method predominated.

Purpose of the Exhibit.

It may be well at this point to give the purposes of the "Chemistry Exhibit." The objects of our demonstrations were three: first, to acquaint prospective students, parents, and others interested in our school with the work of the Chemistry Department; second, to add interest to the work, that is, to motivate the course; and third, to give the class a review of the more important principles of the year's work. I feel that in all three purposes our exhibit was a success. The laboratory

was packed with students, parents, teachers, members of the board of education, in fact with everyone at all interested in our school. Several students and teachers from a neighboring high school visited us and were very enthusiastic in their praises. The local newspaper published a column written by the editor. The class was certainly called upon to review their chemistry because every student of high school age dreads showing his ignorance in public. I feel that for the same reason students became more interested in their work. I made a special effort to select topics which would form interesting projects.

List of Projects.

The list of possible projects for an exhibit of this kind is not at all limited, but I had centered my work upon the essentials, air, water, salt, and substances related to these for the first semester's work; and upon the industries for the second semester. I therefore selected projects that were related to these subjects. Some of these projects were:

1. What materials are present in our drinking water?
2. How can the liquid be separated from the solid in liquid shoe blackening?
3. How may salt crystals be prepared?
4. How may a match be made?
5. What is formed when coal is heated in the absence of air?
6. How can cloth be dyed?
7. What relationships exist between the important chemical in-industries?
8. What does glass do when heated, blown, and annealed?

This is not a complete list of the topics treated but will suffice to give you an idea of what our exhibit was like.

Method Not Subject Matter.

Although the titles I have used are those found in some laboratory manuals, I wish to call your attention to the fact that the method of procedure was different. Because we are using a different method of instruction, it is not necessary to teach an entirely different subject. The procedure was not to follow directions in a book, but the student was constantly motivated by a desire to solve a problem so as to get information to be given to the public at the time of the exhibit, and usually this was a problem which the student himself was interested in.

Procedure in the Project.

One of the most important of these projects was that which

dealt with the relationships between the industries because it was really an outline of the semester's work. While this project is different in many respects from other projects, the method used is about the same. The principal difference is that the student already knows much of the necessary information but is here called upon to coordinate that knowledge. Of course, in order to do that, he must proceed just as he would to solve any other problem. The results of this particular problem were exhibited in the form of charts. Perhaps a better idea of this project may be had if we review the method from the teaching standpoint. I had been constantly emphasizing the importance of such industries as coal, iron, petroleum, cement, glass, fretilizer, soap, dye, and explosives. When the time which I thought psychological arrived, I asked the class to tell me the relationships they remembered. Many interesting facts were given, but the arrangement was not complete. A few became interested; so I put the class to work gathering information. The students most interested made charts showing the uses of common materials in the industrial world. The student that did the best work was put in charge of these charts at the exhibit. The information was secured from pamphlets, magazines, books, and visits to local foundry and canning factory. Of course where it is possible, the best way to secure information of this sort is to make inspection trips to the factories.

Conclusions.

The conclusions to which I have come may be of interest to you. I found that there was no revolutionary effect upon my students; they did not change into highly skilled scientists as a result of this work; nor were some of them especially well informed on chemical subjects. My class remained boys and girls with very much the same desires. Yet I feel that the work was worth while, that they knew more chemistry at the end of the year and would remember it longer than if they had not taken part in the project work in preparing for our demonstrations. I also conclude that there are times when our methods may vary. There are times when the best method is to tell the student what you want him to know; at other times it is better to add a demonstration, or supervise his study, or have him recite on a lesson assigned. But there are also times when it is necessary to review the work, and times when it is advisable to promote the attitude of research. In chemistry

teaching, the field of the project is to accomplish this review by coordinating the work done, and to promote this attitude by arousing the student's attention to the laws of cause and effect. For these purposes no method is better than the project, especially if given the added socializing feature of collecting information to be presented to the public. Laboratory work thus carried out will prove of value to the pupils; the community is bound to realize that the student and teacher are doing work that is worth while even if no examinations are given or passed. If our teachers can present the case in our university and college circles, it will not be long before they will realize that such methods of teaching are practical and efficient; that such teachers are educators, not simply task masters and parrot trainers.

THE RELATION OF THE SECONDARY SCHOOL TEACHER TO THE RESEARCH WORKER.

Miss Marion Sykes,
Bowen High School, Chicago.

Obviously the secondary school teacher is dependent on the research worker for new developments in his subject. This fact is so evident that it needs hardly to be mentioned. A person who finds secondary school work worth while at all discovers that his interest is first of all in the young people with whom he deals, not so much in his subject. He is teaching boys and girls, not Latin, or mathematics, or English, or geography. If he would, he has little time for investigation. In the large secondary schools, a teacher meets from one hundred to two hundred fifty pupils in his classes every day. Not many teachers meet so few as one hundred pupils. So his dependence on the research worker for new light on his subject is very real.

The research worker is the instructor in the normal school, college, or university where the secondary school teacher is prepared for his work. The point of view in these classes is so often that of the specialist that the readjustment of the young person who goes into secondary school teaching is often difficult and long. His college instructors were specialists whose interests were in the subject, and the young teacher carries into his new work something of the same attitude, only to find that a readjustment is necessary if he is to succeed. We hear a great deal of the poor preparation of high school teachers and their lack of training in their particular subjects. There is undoubtedly cause for this criticism. The secondary

school teacher may be too much of a specialist. Often much serious difficulty occurs because the methods and subject matter of the college are carried into the secondary school where they ought not to be. Both the college instructor and the student preparing for teaching, must realize that the interest of the secondary school teacher is in his pupils, and the choice of subject matter and methods depends on the pupils' needs and interests. The object is not to give them a logical, comprehensive view of the subject, but to give them facts that they will use, and to train them in solving problems so that they may each take a useful place in society. College and university training without this point of view does not develop the best teachers for the secondary school.

We in the high school are somewhat dependent on the research workers for our text books. High school teachers have had the courage to tax their time and strength for the writing of text books. When they do this, some of their university and college friends wonder if their knowledge of their subject is sufficient to warrant the undertaking, forgetting that what the high school pupil needs is a book so simple that he can read and understand it, dealing with phases of the subject which touch life as he knows it, and giving him only the most obvious facts which he will need later on. He does not need a carefully compiled, logically arranged treatise on the subject.

The work of investigators in departments of education is becoming increasingly valuable to teachers of all grades. The intelligence tests which are being worked out, are of great assistance in classification of pupils. In the subjects presented in the secondary schools there can not be worked out standardized tests in such detail and definiteness as has been done in silent reading, arithmetic, writing, spelling. There is a certain definite minimum in arithmetic which the experience of civilized man has made desirable to be acquired by everyone. We are all agreed that ability to read with understanding, to write legibly, to spell words in common use, should be acquired by every citizen. But who can say in such definite detail exactly what should be the possession of those who study history, geography, botany, zoology, chemistry? Time was when people thought it desirable to put into spelling books unusual, peculiar, little used words. Now we have careful studies made of the words most commonly used by children in their own activities; studies of words used most commonly in newspaper

and magazine articles; of those used by standard authors. These lists are the basis of work in spelling. Those who are writing text books to be used in the secondary schools need to be in close touch with the departments of education in their institutions, in order that they may profit by such studies. An investigation of the geographical facts most often referred to in non-geographical articles in newspapers and magazines, in the routine of the business office, in classes studying botany, zoology, history, would give an excellent basis for the material to be presented in a high school geography text book.

Such subjects as geography are useful not only for their information content but for the power they develop in making judgments, and solving problems; and text books should be so written as to develop this power. The research worker who undertakes to write a text book for use in the secondary school, but who does not know the needs of the secondary school pupils, and who is not in touch with the work of some department of education, is making a great mistake, and is losing an opportunity to give us a workable, helpful book.

I assume that I am talking to persons who are mostly research workers. We in the secondary school acknowledge our dependence on you, a very real dependence. But when you are preparing young men and women to join our ranks and when you are writing text books which you hope we will use, please remember that our interest must be primarily in the teaching of the child, not in the subject.

THIRTY THOUSAND DOLLARS FOR BIRD PICTURES—FREE NATURE MATERIAL FOR TEACHERS.

Announcement was recently made that the sum of $30,000 has been placed in the hands of the National Association of Audubon Societies to aid teachers and pupils in the study of wild birds. Children will be taught to build bird boxes, feed birds in winter, to learn the names of the common birds in their communities, and will be instructed in the value of birds to mankind.

In making the announcement, Mr. T. Gilbert Pearson, President of the National Audubon Societies, at 1974 Broadway, New York City, made the statement that teachers who form Junior Aubudon Clubs would receive free material to aid in their work of teaching bird study.

"Pupils who become Junior Members will receive material that costs us $30,000 more than their nominal fees," said Mr. Pearson, "already more than one million, seven hundred thousand children have been enrolled in these Junior Clubs in the schools of the United States and Canada, and we have colored pictures of birds and other material on hand to supply 200,000 more children during the spring months. Teachers everywhere are invited to write and secure free the Association's plans for bird study."

THE PROJECT AND PROJECT METHOD IN GENERAL SCIENCE.[1]

By Garfield A. Bowden,
University School, Cincinnati, Ohio.

The Master of Project Method.

In Dole, France on Friday, December 27, 1822, at 2:00 in the morning, Louis Pasteur was born. The event was unheralded and quite unknown outside of the usual circle of family relatives and acquaintances of the neighborhood. At Villeneuve l'Etang on Saturday, September 28, 1895, at 4:40 in the afternoon occurred the death of Louis Pasteur. The death of the "First Man of France" was lamented not only by the great civic and scientific circles but by the lonely shepherd on the steeps bordering the foothills of the Urals and the rough caravan trader of the Orient, in short, from the far corners of the earth came expressions of regret mingled with gratitude in memory of a common benefactor. Indeed his name had already become a noun or a verb or both in nearly every written language. This man had become world famous, world honored and world beloved, solely by his own achievements. No army or navy, no inherited kingship or emperorship, no political, industrial or religious revolution brought about his rise to the pinnacle of world recognition—simply the inheritance of an intellect which he willed and purposed to the service of humanity.

Rene Vallery-Radot, his son-in-law, records that "he was full of projects, and what he called the 'spirit of invention' daily suggested some new undertaking." The nature of these "undertakings" are suggested in the following statements:

1. To establish the truth or falsity of the so-called "spontaneous generation."

2. To discover causes and effect remedies for the "diseases" in vinegar and wines.

3. To discover causes and effect remedies for "charbon" or splenic fever.

4. To set forth to the world the "germ theory of disease."

5. To establish by public experiment at Pouilly le Fort the success of vaccination as a preventive for splenic fever.

6. To make a study of the hydrophobia problem and to work out a preventive treatment of rabies.

The above projects in the order stated, associated with in-

[1]Read before the General Science Section of the C. A. S. and M. T., Soldan High School, St. Louis, Missouri, and read before the Parent-Teachers Association, University-School, Cincinnati, Ohio, Dec. 1, 1921.

numerable others, presented themselves to the mind of Louis Pasteur in the short space of twenty years. Pasteur's attack and successful conclusion of the above "undertakings" so related to the surety and happiness of life is well known and needs no recounting here, but a resume of Pasteur's method of conducting a research is worthy of serious attention, for, by so doing, we provide an opportunity for examining the "workings of a project method" in the hands of a master workman.

The Status of the Hydrophobia Problem Previous to Pasteur's Attack.

The most interesting of Pasteur's projects in preventive and curative medicine is concerned with his investigation of the dread disease of hydrophobia in man and rabies in animals. Prior to Pasteur's successful combat, hydrophobia remained one of the most mysterious and most fell disease to which man is subject. Homer has a warrior called Hector a mad dog. Aristotle speaks of the transmissions from one animal to another through bites and says that man is not subject to it. Some three centuries later Celsus records, "The patient is tortured at the same time by thirst and by an invincible repulsion towards water." The historical methods of treating this disease were stupid, torturous and criminal. The use of corrosives and various caustics and cauterizing of bites with a red hot iron were advised. As a cure, Pliny the Elder recommended the livers of mad dogs. Galen opposed Pliny's recipe with a compound of cray-fish eyes. During the reign of Louis XIV sea bathing, heretofore unknown in France, became a fashionable cure for hydrophobia. These and many other quack remedies were the vogue. The long period of incubation required for the development of this disease only added misery and desolation to the unfortunate victims of the bites of rabid animals. They were outcasts to whom quarter and comfort were seldom, if ever, given. In many sections it became the custom to shoot, poison, strangle, suffocate or drown persons merely suspected of hydrophobia. As late as 1819 the Paris newspapers related the death by strangling and smothering between mattresses an unfortunate person suspected of hydrophobia. In 1831 Pasteur, a child of nine years, witnessed the terror spread by a rabid wolf and had seen the wounds of a victim cauterized with a red hot iron at the smithy. The cauterized victim lived, but several others after horrible

sufferings succumbed to the dread disease. Amidst the various researches undertaken by Pasteur one study was placed by him above every other, the one mystery of his mind—the mystery of hydrophobia. Yet Pasteur was near his sixtieth year of life before he found himself prepared and ready to attack this most fateful of all diseases.

PASTEUR'S ATTACK AND SOLUTION OF THE HYDROPHOBIA PROBLEM.

In the foregoing we set forth the conditions in which Pasteur found a research problem. Now let us examine and observe the methods of attack, of procedure, of organization and of definition that Pasteur employed in order to bring about the solution of the problem in hand. Let us observe the advancement made in each step taken, and how the results obtained at each and every step pointed out to his keen and plastic mind the next required step and thus to the successful termination of the undertaking. The major steps in the solution of the hydrophobia problem were as follows:

1. To begin, Pasteur made a study of rabid dogs. Countless laboratory experiments were carried on while making this study of rabid dogs. This first step led him to conclude that the virus had its seat in the nerve centers.

2. A closer study directed at the nerve centers led him to inject a portion of the matter of the spinal column of a rabid dog into the body of a healthy dog. Results of such injections invariably produced the symptoms of rabies.

3. The next step was to endeavor so to modify and weaken the virus as to enable it to be used as a preventive or as an antitoxin. This proved to be a vexing undertaking, but after long and serious labor he obtained the much desired result, namely an inoculated dog to be immune when bitten by a rabid animal.

4. But this was not enough. Would the inoculation of the attenuated virus have a remedial effect on an animal already bitten? A number of dogs were inoculated, the same number were untreated, and both sets bitten by rabid animals. All treated dogs lived; all the untreated died from rabies.

5. It was, however, one thing to experiment on dogs, and quite another to do so on human beings. Nevertheless Pasteur was bold enough to try. The trial was successful and by so doing he earned the gratitude of the human race.

This simple portrayal of Pasteur's activities may be misleading to some of us. We may think that the passing from step to step was a very simple matter, and that Pasteur saw from the beginning a well defined method of procedure that was certain of the desired results. Such was not the case. Each step taken was beset with difficulties and obstacles that required a sacrifice of mind and body that few men care to make. Literally hundreds of experimental trials and retrials were made at every step in order to obtain an insight that would point out the next successful step. This recital of Pasteur's attack, his conquest, and triumphant victory over this disease lays before us the "workings of the project method" in the hands of a master.

Characteristics of the Project Method.

Time and space prevent the consideration of the other masters in other fields of activity. Suffice to say, however, that Galileo, Lavoisier, Davy, Faraday, Kelvin, Ramsay and others exemplified throughout their lives and undertakings the principles of the project method. The method employed by the masters is simply a natural method of procedure that may be analyzed into the following characteristic stages that are more or less interrelated than well defined:

1. A doubtful or perplexed state of mind regarding a given question, problem or situation.
2. A conviction that the problem or situation is worthy and reasonably possible of solution.
3. A quest in search of information and experience pertinent to the problem or question in hand.
4. An establishment of theories, guesses, or hypotheses that serves as a means to the end.
5. An arrangement or a formulation of facts and evidence that follows through to successful conclusion—a conclusion that dispells the perplexity of mind—a conclusion that may or may not be final.

The identities of the project method as set forth above are not only characteristic of the activities of Edison or Michelson or Madame Curie, but of children before entering school and of children and teachers out of school. In short the project method is a natural procedure undertaken by a self willed individual or individuals in quest of pertinent information that will dispell to a more or less degree a perplexity of mind.

PROJECT METHOD DEPENDS UPON THE PURPOSE OF THE COURSE.

Now is it possible to adapt the method of the scientist to children pursuing a course in general science? The answer to this question is determined solely by the purpose we assign to such a course. If we as teachers use the course as an opportunity to impart our knowledge of the subject matter or to merely interpret some one else's knowledge of the subject matter as set down in a text, we shall have succeeded as haranguers and interpreters to an audience who listens well today and forgets much tomorrow. On the other hand if the purpose of the course is to provide an occasion means by which the children are stimulated to seek information in the achievement of ends sought, then the method of the scientist—essentially the project method—is adaptable.

THE NECESSITY OF A SCIENTIFIC ATTITUDE.

Teachers who are in the habit of assigning so much codified subject matter accompanied by a set of formal experiments, lecture or laboratory, fail to develop the scientific attitude in their pupils. A course in any science that makes no provision for initative on the part of the pupil, no provision for the selection of facts according to their value, no provision for trial, no provision for creative thinking can ever boast of imparting to the least degree the spirit of scientific attitude. Without a development of a scientific attitude how can there be growth of power in the judgment and appreciation of values? Without the scientific attitude how can there be any desire for nice discriminations—accurate selection or rigid elimination?

THE PROJECT.

Thus far much has been said about the project method and little about the project. This condition of affairs is deliberate. For the writer contends that if one is familiar with the project method, the concept of what a project is and what a project is not is quite obvious. So long as Pasteur viewed from a distance the hydrophobia problem it remained a problem. But the moment that he challenged the problem, the moment that he began to investigate it in its own field of action, the moment that he began to define it or establish an hypothesis concerning it and to draw conclusions which would verify and thus directed his labors to bring the undertaking to a successful conclusion, that moment the problem became Pasteur's project—Kilpatrick

would say "the purposeful act" of Pasteur. In the pursuit of this project Pasteur consumed a great deal of time and energy. Indeed at one stage of its development Pasteur found himself physically wrecked and invalided, yet he prevailed and succeeded in driving the undertaking to a successful conclusion. This element of success has become indentified as a fundamental of the project. Again Pasteur pursued his project in surroundings that were wholly fitting to the question in hand, that is, the setting was natural. In summary, then, a project is a "purposeful act" pursued in a natural setting to a successful conclusion.

FORMAL METHODS VERSUS THE PROJECT METHOD.

From the foregoing considerations we readily see that there is nothing new in the project or project method. Indeed, it has been used to a greater or less extent throughout the schools of the land by teachers who sought to inject into their several courses an actuality and a worthiness of enterprise that could not thus be obtained from the old and time-honored methods known as topic, problem and question. The teacher of general science may assign topics on ventilation from the text in hand, from references, or, in fact, may develop the principles from drawings on the board or chart and require the pupils to acquire a mastery of details and principles thus assigned and presented. This method of procedure is convenient, and it is, indeed, quite the habit. It is not problematical to say that the majority of the children have had no previous interest in the topic or subject thus assigned, no "set of feelings" of decided worthiness established in behalf of the question in hand. However, the discipline of the school demands preparation, a preparation of an artificial sort.

On the other hand the teacher may do the more natural thing which is that of having the pupils and himself observe and make a study of the ventilation of the room in which they find themselves situated, and from thence to that of the building in which the room is located. This sort of procedure arouses an interest that aids to establish a "set of feelings" for the thing in question. Such a "set of feelings" usually urges the possessor to seek further satisfaction by continuing the investigation of the affair. Such pupils will of their own accord investigate the home heating plant and modifications of the same as found in various other types of buildings. In fact, if the teacher is

in the habit of approaching the situations and problems of the course by examining the situation or problem as it exists in the child's environment—home and community—the child soon forms the habit of "carrying on." A multitude of minor and personal problems will occur to him. Some of these problems will be found worthy of acceptance, investigation, and definition, and indeed, they will have become "purposeful activities." As such a course proceeds, the spirit of inquiry develops as a logical sequence.

The results obtained from this latter method of procedure are denied and contested by those teachers who have always made use of the more formal and time-worn method of demanding a knowledge of fact and principle in priority of a study of the situation or problem in its natural setting. The course that demands priority of fact and principle seldom, if ever, develops a scientific attitude. Indeed, why should it? The child who finds himself in such a course has no need or use of a spirit of inquiry, for fact and principle *are learned* from the first, and hence the fact or principle becomes for the child a sort of a fairy wand which, when applied with proper rite and due ceremony, dispells or transforms the problematic situation that arises later. Such a child has had his intellectual appetite satisfied with no accompanying mental digestion.

A Background that Fosters a Spirit of Inquiry Is Necessary.

Teachers who have never used the project method in the sciences should not attempt the method on a twenty-four-hour decision. The project method requires preparation, tact and patience. At first the results are discouraging. The pupils have been and are pursuing courses in other branches that are largely formal, and the pupils are so accustomed, and hence their conduct in which a project method is used for the first time is not one from habit. Right habits and attitudes will develop in direct proportion to the development of a spirit of honest inquiry into the how and the why of things. At first the background of the course should give rise to simple problems in which the pupil sees a possibility of solution and a worthiness of pursuit. The following exemplifies the point in question and is a verbatim copy of a reported activity of one of the girls of the eighth grade general science course in the University-School at Cincinnati. The problem arose out of a background that had to do with clothing materials.

M.........F........ University-School
Grade.........8......... General Science

Heat Conducting Properties by Woolen and Cotton Materials.

The question was put before the class, "Which is the better material for winter wear wool or cotton?" Deciding to find out, I took two similar tin cans, a piece of serge and piece of gingham, two corks and two thermometers.

I took the cans, put a hole in the top and also a hole through the corks by means of a file. I then put on the lid of each can and put two layers of serge around one can and two layers of gingham around the other, also over the tops and bottoms, leaving a space in the top of each directly above the holes so that I could put in the cork and the thermometer. Then I took a funnel placed it in the hole and poured the same amount of water in each.

I then pushed a thermometer through each cork and put a cork in each hole. The readings were:

	Time	Cotton	Wool
October 22, 1921.	3:47	83°C	82.5°C
	4:32	61	63
	5:10	52.5	57
	6:07	44	50.5
	7:05	37	45
	8:17	31.5	41
	9:26	27	39.5

In 5 hours and 39 minutes, can with the cotton material dropped 56°C. and the can with the wool dropped 43°C. Altogether the can with cotton dropped 13°C more than the can with wool.

Conclusion:

Cotton is a much better conductor than wool. This also explains the reason why we wear clothes of cotton materials in summer rather than woolen ones. It also answers a question I saw the other day about firemen wearing woolen shirts in summer time. The fires that they tend are hotter than their bodies. The woolen shirts are poor conductors and keep the heat away from their bodies.

While the above exposition of affairs is somewhat awkward, it sets forth, an order of events that is unmistakable and worthy of merit. A mastery of simple perplexities lays a basis for the attack and mastery of the more complex. If a pupil fails to master a task set by another the failure is often excusable, but when a pupil undertakes a self-set task and fails, his self-confidence is weakened—especially so, if the background from which the problem sprung held forth glittering possibilities that were from the first untenable. A course in projects does not mean the complete elimination of the topic, question and problem methods of instruction. These latter methods are enriched and made more possible when preceded or accompanied by related projects. In setting forth a course in general science by means of projects the teacher is the skilled tactician, the silent general who guides and directs the uninitiated from the mastery of simple mysteries of life and nature to those more complex. Serfs and slaves had their tasks assigned, and moreover task masters set over them to drive them to the conclusion of *the* task—not *their* task. When "knighthood was in flower" this condition of affairs was acceptable.

ELEMENTARY SCIENCE IN THE ELEMENTARY SCHOOLS OF ST. LOUIS.[1]

By L. M. Dougan,
Eugene Field School, St. Louis, Missouri.

What we call elementary science in St. Louis begins with the seventh grade. Below that point we call it nature study and under that title we teach a series of lessons on plants, mammals, insects, stars and topics connected with oral geography. Such lessons often take the pupils to the zoo, or the botanical garden and occasionally into the open to observe the subject of the lesson as found in nature. Considerable material is brought to the schools from our educational museum each week. Such lessons are designed to furnish the child with images of sound, movement, color, size, shape or whatever other aspect may have most significance for children. It is to be hoped that in this way a foundation may be laid for somewhat more serious work in the upper grades. The work with little children in a big city is necessarily fragmentary. The observations and the expression thereof are crude. So is all elementary school work, but it must have a beginning, and the best development we can give it.

Beginning with grade 7 we treat in a somewhat more mature way the more common household devices and chemical processes, the physiology of the human body and the phenomena of the weather and thereby try to teach how man uses and controls air, water, food, trees and clothing. As a sort of syllabus and teacher's guide we use *The Science of Everyday Life*, by Van Buskirk and Smith. This work we call elementary science. As in the lower grades, we try to keep the nature study idea in mind, namely, to deal wherever practicable with a large whole first and to develop first the child's interest in the whole leading him by the method of attacking some simple problem or project to an elementary understanding of the laws and principles by which the thing is governed and made to serve man. For example, we encourage the child to think of the locomotive as a wonderful machine, shortening distance and ministering to human welfare, while he is led to understand how it is driven by the expansive power of steam.

It is hoped that ultimately he may come by this road to think of heat as a form of energy. Out of such study we hope for these five results:

[1]Read before the General Science Section of the C. A. S. and M. T., Soldan High School, St. Louis, November 25, 1921.

1. A greater interest in the things studied, leading to a better appreciation of allusions to them in literature.
2. Greater knowledge of how to use and control the things studied.
3. Some understanding of the principles governing them.
4. A more rational habit of observation and study.
5. A better preparation for choosing and pursuing courses in the higher schools.

For projects or problems for study we look to the home, the neighborhood, the school; and, in the selection, we are guided by the pupil's special interest and opportunity for study, and in some cases by the teacher's special knowledge and skill.

Methods.

No order of procedure for the teacher should be prescribed, but the following outline of methods is offered for the benefit of those who may need it.

1–1 Survey of the field of a given project, e. g., How We Heat Our Homes.
  1–2 Some short snappy story as introduction.
  2–2 Different methods known to be used.
  3–2 Methods used in individual pupil's homes.
  4–3 Interests of different pupils as basis for assignment of problems.
2–1 Assignment of problems.
  1–2 To individuals.
  2–2 To small group.
  3–2 To entire class.
4–1 Report of solution.
  1–3 By whom.
    1–4 Individual for himself.
    2–4 Individual for group.
    3–4 Entire class piecemeal.
  2–3 How.
    1–4 In writing.
    2–4 Orally.
    3–4 By drawings.
    4–4 By construction.
5–1 The class excursion.
  1–2 Statement of class project or problem.
  2–2 Careful outline of procedure in advance.
  3–2 Observations on way.
  4–2 Observations on scene of lesson.
  5–2 Development and assignment of problems on scene.
  6–2 Summary and reports on return.
6–1 Clearing up and testing.
  1–2 Comparison and discussion of difficulties by pupils.
  2–2 Suggestions by teacher for further observation and reading.
  3–2 Oral cross-questioning by teacher.
  4–2 Written tests as suggested.
7–1 Summary of project.
  1–2 Laws and principles involved.
  2–2 Application of same to other projects.

General Suggestions.

1–1 Read carefully *The Science of Everyday Life*, pp. i-vi and 393-411.
2–1 Attack the work systematically, preparing for it each week in advance.
3–1 Study the economy of time and effort by correlation.
4–1 Study and teach the use of all the senses.
5–1 Study the selection of individual projects and problems.

6-1 Keep a note-book of your experiences and a scrap-book of teaching material.
7-1 Encourage children to make and collect apparatus for their own school and the educational museum.
8-1 Make your own survey of your district.
9-1 Teach pupils to draw freely as you have taught them to speak and write.
10-1 Organize groups to apply what they have learned.
11-1 Do not be deterred by mistakes or by lack of complete information on your own part.
12-1 Study how to secure close cooperation between school, home and business firms.

GENERAL SUGGESTIONS.

1-1 The recognition of phenomena.
 1-2 Name some object in this room that shows an effect of the sun's rays.
 2-2 In what kind of weather does the electric trolley emit most sparks.
2-1 The interpretation of phenomena.
 1-2 Why does smoke from the chimney go nearly straight up on certain mornings?
 2-2 Why is green wood difficult to burn?
3-1 Knowledge of facts.
 1-2 Make a drawing showing how the paths of rays of light are changed by the crystalline lens of the eye.
 2-2 What causes wind to blow?
4-1 The application of knowledge in doing things.
 1-2 Remove a spot of butter from a piece of woolen cloth and show the result.
 2-2 How would you install a new fuller ball in a leaky faucet in your home?
5-1 The appreciation of aesthetic and economic values.
 1-2 Why do people still build open fireplaces?
 2-2 Why do we call the telegraph a great invention?

Note: Answers may be graded as:
 a. Complete. b. Incomplete. c. Vague. d. Wrong.

So much for what we ought to do. How stands our record of achievement? Roughly, we succeed in so far as we furnish the following essentials:

1. A teacher with a vision of what this work means to a child of 12 or 14 years.
2. A teacher who has a fair command of the fundamentals of physics, chemistry, astronomy, botany and zoology.
3. A teacher willing to survey the full resources of the district in which she lives *and works*.
4. A scheme of grading pupils which is workable.

TESTS.

We recognize the danger of setting fixed standards and the futility of trying exactly to measure thereby either the pupil's general powers or the teacher's success. The following specimen questions are offered to help the teacher better to measure and improve her work.

Obviously, this is asking more than can be expected, except in favored schools. Teachers such as we have in mind are quickly drained away by the higher schools at more salary than elementary schools can pay and many profess to believe that the junior high offers the only solution. G. Stanley Hall used to say that the right kind of teacher could teach the fundamentals of any subject to elementary school pupils; but if the teacher cannot be had the teaching is not likely to be done. No doubt the high schools too, need the superior teachers.

Our St. Louis system of grading classifies the pupils of a given school grade in four sub-grades, each ten weeks apart. Each teacher in a standard elementary classroom has two classes sometimes in the same sub-grade (quarter as we call it) and sometimes in two sub-grades either ten or twenty weeks apart. Each such classroom has on the average above 40 pupils, often nearly 50. A considerable number of our schools have organized their upper grades under the departmental plan and thereby gained somewhat in teacher-efficiency. A few have tried to organize the two classes in a given room into three groups according to native ability and age rather than previous school record. This is the method of our Blewett Junior High School where with small groups in separate rooms good progress is no doubt made. Most of us in the elementary schools feel, however, that any teacher with more than 40 individuals on her hands at once in teaching elementary science has more irons in the fire than she can keep at the right temperature. Our grading problem is further complicated by the difficulty of establishing and maintaining similar standards in all the similar schools of a big city, so that when pupils transfer, as they so freely do, much loss and confusion results.

We have therefore to work and wait not only for more trained and selected teachers recognized and paid in the elementary school as well as in the higher schools for the same quality of teaching but for smaller numbers in our classes. Meanwhile it is necessary, in season and out, to educate all school people to a better understanding of the importance of elementary science in the general education of the masses.

The high school will need to go on with the work but we of the lower schools must lay the foundation. Our advance must be slow under present conditions, but our successes in the last decade justify the hope of further progress.

PROJECT METHOD IN MATHEMATICS.[1]

BY BYRON COSBY

State Teachers College, Kirksville, Mo.

The term "project method in teaching" has been defined in various ways. It is somewhat like the heuristic method. The primary idea is to develop plans of motivation, and adjust the boy or girl in the search for material into larger or more complex experiences. In attempting to understand the project method, we think of at least four primary definitions: First, to make or construct something as the building of a castle in the history class or a table in the Manual Training Department; Second, to do the thing for pure enjoyment, as going to a show, sketching the landscape or attending a basebell game; Third, to set a problem that provides real situations, as a study of irrigation, dry farming or the building of a house; Fourth, to teach the fundamentals so that the children can appreciate the value of certain facts and experiences of their associates.

In presenting mathematics to the learner, the problem should be stripped of all difficulties due to vocabulary or sentence structure. The child should be taught with the problem, the appreciation of the economic notation, the power and greater independence given through its solution and its place in his world, together with its relation to the world into which he is venturing. This means the child must make use of the information that comes to him in daily life.

When the child recognizes that he has the proper tools for working and some knowledge of and skill in using, he senses the practicality of the subject and attacks the problem. The plan obeys the laws of habits, gives a chance for synthesis as well as analysis, induces the child to associate effort with interest, relieves him of dependency upon textbook and makes him comfortable.

Recently on my way home from work, I was stopped by a small group of men. One was a probate judge, another a Presbyterian minister, and the third a merchant. All of these men were mature, and as the world judges men, they were educated. A problem had attracted their attention. The municipality was extending its lighting system. The workmen had left a piece of apparatus with two wires attached as though the work was completed. One of the men asked me what it was for. I had no answer. The problem held an interest and they did as the adult

[1]Read before the Mathematics Section of the C. A. S. and M. T. at Soldan High School, St. Louis, Mo., November 25, 1921.

mind so often does, consulted someone else. We called a neighbor, who in early life had been an engineer, but who for twenty years had been a loan agent, and his answer was as evasive as that of any expert. He said, "I never studied telephony." While we were in this complex situation, a ten-year-old lad came by and said, "What's the comedy?" One of the men replied, "We do not understand why two electric light wires should run to a brace and end." The boy answered, "They do not run to the brace and end. The men have just quit work at that point, and tomorrow they will continue the work and lead the wire back to the generating plant." The man of fifty, educated in the isolated topical plan of yesterday, does not have the power to attack the unknown problem. The adult has learned how to function in his problems of daily life. His problem material covers a very narrow range. In working hours, he knows only the isolated problems of a routine business. In his leisure time, he tries to avoid problems, and failing asks someone else to give the solution. The problem material wherein he functions regularly he does more or less well, but usually in a very wasteful manner, because he tries to fit this material into some organized formula. He knows only the mechanical rule. He wants certain pieces of furniture in the living room, other pieces in the library or kitchen, and his working tools at his desk. The healthy boy of ten finds it just as satisfactory to leave his football in the dining room, his riding togs in the library, and his bicycle on the front porch or elsewhere. He is not bound by needless conventions. He is elastic; he has power.

The ten-year-old lad mentioned above has initiative power and has not been isolated by mulling over rules and formulas. His teacher for the past three years has been a mature woman, with a master's degree from the Teachers College, Columbia University, and who knows, (1) that a problem is to be stated in simple terms, both the parts given and the parts required, (2) that appreciation of the problem material presents roads to travel from the beginning to end, and (3) that highly integrated machinery does not have to be set up to solve problems. She does not teach isolated facts, nor rules for assembling them, but rather develops the ability to organize the material needed, the power to attack unknown situations, the value of sustained effort and the beauty of accomplished work. This is what we hope for the project plan.

Our method may be best illustrated by setting certain problems. In our demonstration work in the elementary school, we chose for one of our problems the building of a house. Each child visited some house in the process of construction, then each made tentative floor plans. The best suggestion was chosen. We discussed the contour of the ground, set our levels, established north-south and east-west lines, and investigated the building material. We computed the cubic contents of excavation, the cost of basement floor, the foundation walls, the floor joists and sills, the studding and all other items that entered into the building. While part of the pupils worked upon the building of the house, others interested themselves in interior decoration and landscape architecture. When the problem was finished, we had complete plans and specifications sufficiently correct to build a house. The more elementary children worked out the problems of window curtain and dining room linen; sometimes using newspapers for patterns.

The problem was democratic in that every child had a chance to contribute his information. He had a chance to develop his originality, exercise his social instincts and to obey the motive of conquest. The solution of the problem called for many days of work, but each child worked in his field of experience and natural promptings. No time was lost in setting up false and artificial machinery, either for form or solution. Each child worked his part of the problem. Many problems of this type are suggested, as "An Ideal Dining Room," "An Efficient Kitchen," "My Budget for a Year," "Corn Clubs," "School Gardens" and "A Passbook for One Acre of Corn."

In the high school, we try to orient our problems. Our first axiom is "that every child has a right to know why the problem has been introduced, where it belongs in our social or industrial organization and its relative value." If the problem cannot stand this test, it is dropped. We do not have a fondness for recreational problems in the class room. My beloved professor at the University taught me graphic representation with skill and assurance. I learned mechanically how to find the maxima, mimima, intercepts on Y-line and X-line and the points of inflection. I was able to graph equations with speed and skill, but if he told me the lesson or the function of the graph, I never learned it or else have forgotten his teaching.

I do not understand why our writers of algebra do not introduce graphic representation with a study of the location of

geographic points by latitude and longitude, with the equator and prime meridian instead of X-and Y-lines; or the units of measure, township and range, with the base line and principal meridian or again the simple problem of locating school, church or home on the town map. Every child in a Missouri high school knows the problem of latitude and longitude; the problem of range and township and how to locate a house by street and number. A statement concerning the parabolic reflector of the railway engine and motor car, of the path of a projectile or falling body gives life to the study of the parabola.

In geometry, the work should presuppose a problem that is needed in the community's life, and geometric principles the working tools for its solution. Proportion helps us to read maps, measure inaccessible distances, and determine our possibilities. Internal tangents give us the problem of belts for change in direction of motion, the parallel lines of proper spacing for pictures or dressmaking, and the idea of tangents for laying out beautiful walks. The golden section problem helps in picture making and interior decoration. Symmetry finds its use in architecture, dress, and analagous argument. The geometric principle that areas are proportional to the squares of their corresponding line measurements is found in the problems of sewers, water systems, heating plants, and land drainage. Geometry should be a tool for measuring life, and as such it rarely meets the syllabi so often published.

The advanced mathematics gives great opportunity. All types of investments call for the solution of standard equations. Why clothe logarithms in mechanically artificial problems when we have annuities, amortization, valuation of bonds, sinking funds and depreciation, building and saving associations, the theory of probability and problems in life insurance. Some of the problems of the calculus might be replaced by commecial problems, (1) because we might have as great a future need for commercial solutions as for engineering results, (2) I believe the problem of amortization might be as valuable to the average college student, not the mathematical genius or engineering expert, as "assuming that the values of diamonds are proportional, other things being equal, to the squares of their weights, and that a certain diamond which weighs one carat is worth $\$m$ show that it is safe to pay at least $\$8m$ for two diamonds which together weigh 4 carats, if they are of the same quality as the one mentioned."

Problems in engineering offer many projects. The manufacturing of cans or the building of roads sets a motive that can be easily handled by such mathematical tools as maxima, minima, and points of inflection. For example:

When a road, railroad, or canal is built, the center line is laid out on the ground. The drives of the park system of Chicago are evidently successive arcs of varying radii. Railroad curves are ordinarily smooth curves. In Raymond's Plane Surveying, one finds a method for locating arcs approximately by use of the tape.

We make no infallible claim for any method. A poor plan in the hands of a hardworking, painstaking teacher who is definitely interested in the plan may produce good results. The project plan sets a problem in the field of life where found and puts upon teacher, child, and community the demand to read catalogs, magazines, newspapers, to rely upon self, to consult neighbors and to organize material. It requires of the student only what he is ready for, and gives him just what he asks for. It is democratic, in that each child can contribute to the social group, and is honest in that he always works for his ideal and desire and not the artificial findings of some one else. It is not a good plan for the lazy teacher or he whose idol is a textbook. I believe in interest, and effort, and feel that the project method will succeed in the hands of one who wants to work.

GROUP TEACHING IN GEOMETRY.

By Myrtle Downing

High School, Salina, Kans.

Due to the fact that so many boys and girls are attending our high schools today, which necessarily involves a great variety of mentalities, it is essential that we change our technique of teaching. If we expect good quality of work we must necessarily vary the quantity. We must agree that thoroughness is a moral asset as well as an educational one.

Going on the theory—and this is not theory alone—that a miscellaneous group will arrange itself roughly into three groups; the brilliant, the mediocre, and the dull students, the former plan of giving the same assignment to all pupils leads to one of the following results. If the assignment is made to fit the needs of the bright students, the mediocre students do not get anything well, in their effort to do as much work as the bright ones, and the dull students, which comprise about one-fourth the

class, all fail. If the assignment is for the mediocre, the dull students do not get anything well and the brilliant ones do not have enough to keep them busy, and they are not given the opportunity of developing to the best of their ability. If the assignment is given to fit the needs of the poor students, neither of the other two groups have enough to do to keep them out of mischief, and the greatest good is not done to the greatest number. It is one of the outstanding faults of our present school system that it neglects the more brilliant students by not giving them enough to do; they are the ones that can and should become the leaders of our country. We cannot change the material of brain matter, we can only develop that material to its highest capacity. When it is all finished, some will naturally be on a higher level than others.

About the fifth week of school this year, after I had discovered the mathematical ability of each student, I divided each of my sophomore geometry classes into three groups. Group I consisted of the bright students, group II the medicore, and group III the dull. I seated group I on one side of the room, group II in the center of the room, and group III on the other side. I use a definite blackboard space for the assignment each day, which is cumulative. Each group does the work of the lower groups plus the assignment for its particular group. The choice of assignment is something on the following order. Group III works all the important theorems and corollaries, group II all the theorems and corollaries plus some of the exercises, and group I all the exercises in the text and in addition many others. This does not mean that group III fails to have the advantage of any of the exercises. The pupils of this group often listen to the explanations of the other two groups. They are able to follow the explanations, even though they could not possibly have worked them out originally. However, some of the easier exercises might be given to group III. This group would never be able to work out the more difficult ones, even under the former plan of assignment, so why have them attempt something that we know is an impossibility. It is seldom advisable for group I to listen to the recitation of group III. They had better be spending their time on working additional exercises, and it is indeed much more enjoyable on their part. Pupils soon get used to studying while others in the room are reciting.

The plan was thoroughly explained to the pupils at the time of the grouping. They were aware of the fact that some pupils

are naturally more brilliant than others, but they were not used to having a teacher say so. We are in the habit of trying to make pupils think that they can do just as well as anyone else if they only work hard enough, when down deep in our hearts we know it is not true. A student may move to a higher group when he has done the work of that group for a few days, and he may be put in a lower group when he has failed to do the work of that group for a few days. This moving may be done at any time, although it is often advisable to make moves after a weekly test. No work is accepted that is not done exactly right. The dull students can stay with a thing until they get it without retarding the whole class, while the others go on working at something else.

Most of the teacher's time should be given to groups III and II in the form of supervised study. This does not mean that there must be supervised study time. The regular period may be used to advantage in showing the poorer pupils how to study economically and to the best advantage. The better students do not ordinarily need this training. If pupils are taught how to attack a problem, they will develop into independent workers, and in the end will have gained much more than if the entire time had been spent in reciting something they already know about.

Usually the first thing that is asked concerning this idea is: Does it not result in fatalism? That is, do not pupils become discouraged because they are placed in low groups? They always have the opportunity of moving up or moving down, and this has happened in many cases. I have had many pupils in group III tell me that they liked this plan because they understood what they were doing, and for once in their lives they had the satisfaction of having done something really right. Are there not pupils who overwork in their effort to attain or retain a high group? Yes, but it is no more true than the fact that under the former plan these same pupils would overwork to the same degree in trying to secure high grades. There are pupils who remain in a lower group than their ability calls for, but the number is not nearly so great as the number that made it their business just *to get by* under the former plan. Their pride is being appealed to by everyone knowing their standing every day, and the result is that almost everyone is doing the best he can and is placed in the group that fits his mentality. The question of "more work for teachers" is of vital interest and concern. This

does require more planning on the part of the teacher, but it requires less manual labor. The teacher finds out the standing of her pupils much easier, which does away with so many test papers to grade. A group at a time may be tested, and in that way there will be fewer papers all at once. Group I needs very little testing. A teacher will spend her time with those pupils who really need help, and her justice in grading is much more accurate. After getting a good start on this plan, there is very little trouble in carrying it through.

We use the A, B, C, D, and F, system of grading in Salina. Pupils in group I comprise the A and B students, group II the C's, and group III the D's and F's. We are all familiar with the fact that the per cent of failures in the required mathematics courses is entirely too high. If we have any faith in the "normal probability curve," which is no doubt as scientific as anything we can mention at present, there is indeed something wrong with either our teaching or our grading. The first semester of last year I had 19 per cent failures in my sopohmore geometry classes. The first semester this year under the group plan I had 9 per cent failures. I am convinced that this difference is due to the pupils knowing their work better.

Although I have only been using this plan for one semester, I am well satisfied with the results. I believe it is far the best plan to use in a required course in mathematics, where there are all types of pupils in the classes and the division with reference to mentality has not been provided for otherwise.

IS THE TEACHING OF MATHEMATICS AN EASY TASK?

By G. H. Jamison,

Professor of Mathematics, State Teachers College, Kirksville, Mo.

A writer in a recent mathematical journal expressed the thought that there is no subject in the high school curriculum easier to teach than algebra if a standard text is used. One also frequently hears the same utterance with respect to any high school mathematics from speakers who have not had any experience in teaching mathematics and from those who think they are teaching mathematics when in reality they are not teaching at all.

There is much so-called teaching which is nothing more than presiding over a group of students, reading lists of exercises for them, pointing out errors, checking up the final results by

the aid of an answer book, assigning so many problems for the next day and repeating all this to the end of the term. To teach arithmetic, algebra and geometry in this manner is perhaps easier than to teach any other subject unless it be spelling or reading when taught equally as poorly. Suppose we do not call this teaching and try to describe real teaching.

Real teaching of high school mathematics involves a knowledge on the teacher's part of the foundations of the science being taught. The teacher will feel or appreciate the logical development of the subject. The value of the part to be played by definitions and assumptions will be known. In genuine teaching, the art of questioning will be highly developed. It is easy to ask a poor question and often very hard to ask a good question. The good teacher will answer most questions by asking other questions. Good teaching will hardly be exemplified by the one who does all the work and all the thinking. Good teaching insists on the why and how as well as the results. It will make the work in mathematics hard for students because it makes them think. Good teaching will be difficult to do because it requires so much alertness, such skill in marshalling the forces, so much knowledge and such quick reaction to the varying needs of students.

Let us now see if this popular contention about the teaching of algebra being easy is true.

If this subject is properly taught, the class in the beginning will realize that there is but little if any difference from the arithmetic unless it be more of generalization. For many days no new elements will be introduced. Principles long used in arithmetic will be discovered and stated. The student will see that the beginning of algebra is in part the study of a new language. But this is not wholly new for in arithmetic, while studying the topic of mensuration, the rules were often stated in the language of algebra, that is, symbols were employed. The matter of substituting numerical values for letters and evaluating expressions is a topic which causes panics for many students. This has been done in the formulae of mensuration in arithmetic. The teacher's task is to prepare the way for this generalization which differentiates in one respect at least the algebra from the arithmetic, so that the student will see that he is simply going farther than he did in arithmetic. This generalization will one day cause the class to try to subtract any two numbers. Here will be developed a need for the negative number.

To introduce properly the negative number and the operations on it is no easy task. At this point the teacher will need to know mathematical history, as well as the importance of definitions and assumptions. What can be done with these new numbers? Nothing can be done until certain definitions are made. There is need for going slowly but surely at this point. Students need to see that they are being naturally and gradually led into new number worlds, and that they are now placing the foundations, as far as they are concerned, for the science.

Algebra can be made a thought study or it can be made a subject of endless, wearisome drill. If the teacher demands thought her task is hard. If she be indifferent as to whether her students are gaining power to meet new number relations, then her task is easy enough.

Suppose we look at the subject of factoring. To teach this so that power is gained the learner must know the meaning of type expressions. If any teacher has a recipe for teaching types easily, request is hereby made for it. What does it mean to say that ax^2+bx+c or x^2+bx+q is a type? Under which type should $4x^2+3x+8$ be placed and why? It looks as if it would not be hard to get students to understand the type a^2-b^2. As long as the two terms are squares of monomials the student does well, but let one or two of the terms be squares of polonomials and then watch results.

Does the average teacher of high school mathematics who finds the subjects so easy to teach, understand the fundamental laws or assumptions as applied, first, to integral exponents and then fractional, negative and zero exponents? Does the teacher build up the science or force the pupils to do as rules say to do?

Mathematics can be taught, and it is the easy way to teach it, so that students can work problems by the wholesale without knowing how to work them. A student taught by this plan was asked how to reduce 2/3 to twelveths. She replied, "Divide 12 by 3 and multiply the result by 2. This gives 8/12." Good teaching will not allow such a result. It will insist on the pupil knowing how to do things as well as possessing ability to get results. The how and the why of mathematics requires thought on the part of the student and difficult work on the part of the teacher. The results or answers to problems can be had in many ways. From the educational point of view it is just as important, if not more so, to know how to get a result than to be able to get it. Ask a class how to add fractions, clear an

equation of fractions, solve a quadratic equation, plot the graph of an equation, etc., as a test of their ability to state in good English the way to get results. Our students learn a certain rigmarole which kills the true spirit needed in any mathematical endeavor. Teaching mathematics by rigmarole is the easy way. It develops no power in people for clear, concise thinking. This kind of teaching makes pupils as well as the general public opponents of our high school mathematics.

Teachers of mathematics need to realize that their problem is a very hard one. They need to give thought to it. More concentrated effort in our teaching will lead to better results, will remove many of the objections lodged against the science into whose rooms every student should look, many of whom will want to enter and contribute to its development.

THE DICTIONARY OF GEOMETRY.

By Charles H. Sampson

Boston, Mass.

The dictionary of geometry is sadly neglected both by teachers and pupils. It should not be. One can hardly learn to write if the dictionary of the language that he speaks is neglected. One can hardly be expected to think intelligently in geometry if the fundamental truths (the dictionary) are not clearly understood.

A page of definitions or rules is more or less uninteresting reading for the average pupil. There is little to create or promote a lively interest there. And yet, no pages in the text need emphasis more than these. They are the dictionary of the subject.

Proofs or theorems occupy, and rightly so, a most important place in the study of the subject of geometry. A proof, if it be complete, requires statements of fact for which reasons must be given. There is always a "why" to be answered. A proof without reason, is worthless. Correct reasoning depends very largely upon a sound and broad knowledge of the geometrical dictionary.

"The radius perpendicular to a chord bisects it and the arc which it subtends." Here is a short theorem but even here, in spite of the brevity of it, several definitions must be understood if the proof is to be worked out successfully. What is a radius? What is the meaning of perpendicular? What is the meaning of chord? To bisect a chord is to do what to it? What now, does that word "subtends" indicate? Always there is an oppor-

tunity to test one's knowledge of the geometrical dictionary

A good place—in fact, the best place—to start the geometrical ball rolling is in the last two years of the grammar grades (the first two years of the junior high school). Children of the age represented here can visualize and understand the construction of such things as squares, rectangles, triangles, circles, tangents, etc. They can also understand and become proficient in applying the formulas that are used for finding the areas and perimeters of these common figures. To do this at this time is opening the pages of the geometrical dictionary to them. They will enjoy the new knowledge acquired and later on they will profit greatly by it.

It is true, of course, that all of this work will have to be reviewed at a later period but if the foundation is built at a time when the mind is more receptive and keen to learn than is perhaps the truth later on, the review will be easier and of greater value.

There are many ways in which to learn the dictionary of geometry, depending very largely on the way that the subject is taught. Here is a chance to make a teaching problem an interesting one.

The geometrical terms should not be learned as one might learn a poem. No laborious and tiresome memory work should be necessary in the sense generally thought of. Let there always be an illustration at hand. If a rectangle is a plane figure bounded by four sides all the angles of which are right angles, let there be a cardboard figure to illustrate. Children absorb much visually. Let the eye see the definition. The right angles should be pointed out; the fact that one side is longer than the other should be indicated. Explain why this figure is called a rectangle.

Where areas are to be found and perimeters determined there ought to be a definite illustration to tie the mental thought and the visual thought together. The young student is slowly but surely learning his geometrical dictionary.

It is a practical impossibility to teach geometry successfully if the illustrations are neglected. A geometry class room without a blackboard in it is a good way from being ideal. One of the most important and necessary features of such a room would have been neglected if such an aid to teaching were missing. The teacher should use a lot of chalk when teaching rules and definitions. Illustrations are needed if the geometrical dictionary is to be mastered.

TANGENT LINES AMONG THE GREEKS.

By Florian Cajori

University of California, Berkeley, Calif.

Some time in the future I may discuss Professor G. A. Miller's numerous and interesting criticisms of my histories of mathematics, which have appeared in this journal, with the view of determining which of his criticisms are correct and which are false. In the present note I wish simply to enlarge upon his comment on the fundamental question of tangent lines. Professor Miller refers to my *History of Mathematics*, 1919, and says:[1]

"One would probably not regard a statement appearing on page 163 of this history as reasonably accurate. It is here stated that Roberval 'broke off from the ancient definition of a tangent as a straight line having only one point in common with a curve.' It is evident that the ancients might have thought that a tangent line at the point of tangency had only one point in common with the curve, and that they might have concluded that a necessary and sufficient condition that a stright line is tangent to a circle or to an ellipse is that it has one and only one point in common with such a curve but they must have noticed that such a condition is not sufficient to insure that a straight line is tangent to such a curve as the cissoid of Diocles, for instance."

The claim made here that my history is "probably not . . . reasonably accurate" is based on a mere guess on the part of the critic as to what the Greeks might, perhaps, have thought. The critic refers to the cissoid, but he is unable to point out that the Greeks ever constructed, or tried to construct, tangents to the cissoid or that they considered the drawing of tangents at cuspidal points. There is no evidence to show that the drawing of tangents at singular points of curves and the special precautions necessary in treating that subject received the attention of antiquity. Really, Professor Miller's comment is an artistic piece of fiction. What we do know is that the Greeks constructed tangents to circles, to conic sections and to certain other curves having no singular points. For these curves the point of view stated in my history is necessary and sufficient. If one examines the proof of Euclid III, 16, it is evident, not that Euclid "might have thought that a tangent line at a point of tangency had only one point in common with the curve," but that Euclid actually and truly established this to be the case for the circle. If further evidence is desired on this point, it will be found in

[1]This journal, March, 1922, p. 278.

Euclid III, 2: "If any two points be taken in the circumference of a circle, the straight line which joins them shall fall within the circle." Professor Miller's criticism is wholly unjustifiable.

The concept that a tangent touches a curve at only one point was with Euclid a logical necessity. For suppose the tangent touched the curve at two distinct fixed points; these two points could not be consecutive points for the reason that no such points exist on a continuous curve. Between any two points there exist other points on such a curve. If the two points are not consecutive, how was Euclid to distinguish between a tangent line and a secant? A secant may cut a curve in non-consecutive points.

The statement quoted from my History, was made in order to contrast the tangent concept of Roberval and some of his contemporaries with that of the Greeks. Roberval's assumption of two points of contact rested on a crude intuition resembling that which regarded a curve as a polygon. More recently, logical demands have led to the abandonment of Roberval's concept and to a return to that of the ancients, according to which a tangent cannot have more than one point in common with a curve at a point of tangency. Most of the modern processes of determining tangents rest on the theory of limits.

A SCORE CARD FOR JUDGING THE VALUE OF GENERAL SCIENCE TEXT-BOOKS.

By Allan Peterson,

East High School, Des Moines, Iowa.

During the present year it became necessary in the Des Moines schools to adopt a number of new texts in various subjects. To accomplish this Superintendent J. W. Studebaker and his administrative assistants devised a plan of procedure somewhat more systematic and professional than the ordinary.

At the head of the entire work of text-book selection was a General Administrative Committee composed of the superintendent director of research, supervisors and high school principals. This committee outlined the general plan of procedure and formulated the main divisions to be used by all committees on their score cards together with their definite values. These values were derived experimentally by securing the average judgments of eighty teachers, principals and supervisors in the Des Moines schools.

For each subject in which a text was to be selected there was a special Text Book Committee composed of four teachers familiar with that work. These committees first prepared their score cards which they submitted to the General Committee, or in some cases to special Curriculum Committees, for approval. They then examined the various texts submitted, scored them and prepared a final report and summary which was submitted to the General Committee, and through them to the Board of Education.

Publishing houses had previously been notified of the plan and dates were arranged for their representatives to appear before the various committees to explain the merits of their books. No member of a committee was interviewed personally.

Each committee member then scored each text, after which the committee met, compared scores and agreed upon a committee score on each item for each text. A summary of the total committee score for each text was made as well as any recommendations the committee felt necessary. This report together with all individual score sheets was filed with the General Committee.

The General Science Committee was composed of Miss Margaret Brick, of West High, Mr. S. L. Thomas of North High, Mr. C. B. Houser, of East High, with the writer as chairman.

The score card below is not submitted with the idea that it even approaches perfection, but with the hope that it may be suggestive and helpful to others who may be faced with the problem of text book selection. As intimated above the five general divisions and their assigned values were fixed by the General Committee. This was also true for all of Topic V which was the same for all texts. The sub-topics of the first four divisions was the work of the General Science Text Book Committee.

SCORE CARD FOR JUDGING VALUE OF GENERAL SCIENCE TEXTS.

Name of book..

Author..

Publisher..

Scored by..

		I	A
I.	*Interest*	200	
A.	In subject matter (As related to himself and his environment.)		100
B.	In demonstrations and experiments (Manipulations and results.)		60
C.	In supplemental work (Scientific reading and investigation.) (Further scientific study.)		40
II.	*Comprehension*	250	
A.	Of reading matter (Vocabulary and style.)		125
B.	Of demonstrations and experiments (Manipulation and results.)		75
C.	Of tables and illustrative materials (Are they clear?) (Are explanations easily interpreted?)		50
III.	*Permanent Value of Subject Matter*	250	
A.	Is information authentic, practical and of permanent nature?		100
B.	Does it give general view of the field of science? (Pertaining to environment and to the special sciences.)		100
C.	Does it tend to develop power of observation and independence of thought? (Are exercises suggestive?)		50
IV.	*Value of Method*	200	
A.	Arrangement and presentation of material (Logical development.) (Proper subdivisions.) (Helpful illustrative materials.)		125
B.	Opportunities for application of subject matter (Class room exercises.) (Outside work in home and community.)		75
V.	*Mechanical Elements*	100	
A.	Size and clearness of print		40
B.	Distinctness of pictures and maps		5
C.	Size and clearness of print of marginal notes and indices		5
D.	Size and clearness of print of footnotes		5
E.	Width of margins		5
F.	Length of lines		15
G.	Paper		15
H.	Binding		5
I.	Size and shape of book		5

Explanatory Note: The items under A, B, C, etc., in parenthesis, were not assigned any values, but were inserted as explanatory and suggestive for the benefit of the scorer in arriving at the values of those headings.

TRIGONOMETRY WITHOUT SIMILAR TRIANGLES.

By Jos. A. Nyberg

Hyde Park High School, Chicago.

Without discussing whether or not trigonometry should be taught in the ninth grade, the present article considers only a possible method of *introducing* that subject. The word *introducing* is used because I feel that each topic in each week's work in any course should be an outgrowth of the previous week's work. We may, if we choose, flit from geometry to algebra to trigonometry, and flutter to and fro dropping various bits of theoretically useful information at a pupil, but mathematics will seem less artificial to the pupil if his own daily questions are the cues which lead to the next week's work. For some time I have wanted to try the teaching of trigonometry in the ninth grade, but have hesitated such a bold approach as to say to the class "Tomorrow we will begin chapter 14 dealing with trigonometry." Rather I have been waiting for some pupil to ask some question which would serve as an introduction, as an excuse for beginning that subject.

A study of similar triangles usually precedes trigonometry, but similar triangles have not been studied for the same reason that trigonometry has been omitted; namely, no pupil has asked any question or proposed any problem which could best be answered by a study of such triangles. Of course, similar triangles can be used to illustrate proportions, but it is an open question whether a topic should be considered even as an illustration unless it can be treated with some thoroughness. Moreover, knowing from experience how many weeks are required in a geometry class to develop the concept of similarity, I doubt if it can be done in half a dozen pages and a few experimental exercises. As a result of this omission of similar triangles, a discussion of trigonometry has never arisen.

There is, however, a way of introducing trigonometry without using similar triangles. The class had been studying the Pythagorean equation and applying it to finding the base of an isosceles triangle when the altitude and arm were known, or finding the side of an equilateral triangle when the altitude was known. Such problems arise in studying pure quadratics as a preliminary to the general quadratic equation. After solving a number of specific examples some bright and lazy youngster will discover that if the altitude is known, then doubling the altitude and

dividing by $\sqrt{3}$ will give a side of the equilateral triangle. (Paranthetically I might add that the teacher should continue assigning specific examples until some pupil *does* discover this relation, for such generalizations constitute the difference between arithmetic and algebra. And the discovery will be made comparatively soon if we avoid even numbers, multiples of 3, perfect squares or numbers for which simplifications are possible. Also, as each exercise is solved it is well to have some one record at the blackboard the results so that they catch the eye of the pupil). After making this discovery we decide to prove its correctness. It is assumed that the class has previously learned that the use of such numbers as 10, 12, 15 may be valuable in giving a "hunch" of how to proceed, but such numbers are useless in a proof. Consequently we call the altitude h, a side a and proceed to prove that $a=2h/\sqrt{3}$.

Given: equilateral $\triangle ABC$, $CD \perp AB$, $BC=a$, $CD=h$.

Prove: $a=2h/\sqrt{3}$

$DB=a/2$	The perpendicular from the vertex bisects the base in an isosceles triangle.
$a^2=(a/2)^2+h^2$	The Pythagorean equation.
$4a^2=a^2+4h^2$	Members of an equation may be multiplied, etc.
$3a^2=4h^2$	Transposing a^2.
$a=2h/\sqrt{3}$	Members of an equation may be divided, etc.

This proof is used because by presenting a proof occasionally in this form in an algebra class, the work in geometry will seem less strange and artificial.

Next, in various ways we can discover and prove that $h=a\sqrt{3}/2$. In doing the work each pupil has used different lengths for a and h. No two pictures by different pupils would show the same size of triangles. Neither have we used the word similar. But the conclusions hold for every equilateral triangle because the general numbers a and h have been used. Moreover, our discoveries are useful even when no equilateral triangle appears in the picture—for example, in finding the altitude of a rhomboid one of whose angles is 60°, or the altitude of a trapezoid one of whose angles is 30°. By such exercises we shift the attention from the equilateral triangle to the so-called 60-30 right triangle. Hence the class is asked to formulate a statement of these discoveries which will emphasize how to compute the lengths of lines in a 60-30 right triangle without emphasizing

or mentioning how these discoveries were made. The next day we discuss the statements of the pupils, criticizing each for clearness, brevity, awkwardness and even grammar until the class works out the statements:

In a 60-30 right triangle

the side opposite the 60^0 = the hypotenuse multiplied by $\sqrt{3}/2$
= the adjacent side multiplied by $\sqrt{3}$
the side opposite the 30^0 = the hypotenuse multiplied by $1/2$.
= the adjacent side multiplied by $1/\sqrt{3}$
the hypotenuse = the side opposite the 30^0 multiplied by 2.
= the side opposite the 60^0 multiplied by $2/\sqrt{3}$.

Since quite a few exercises were solved in discovering and working out these statements, we do not practice on them further, but begin the problem of finding the corresponding multipliers for a 45^0 angle. Use an isosceles right triangle; call the hypotenuse h, the sides a, etc., and state the discoveries in language like the above. Finally we tabulate our information as:

	To get Opp. side multiply		To get Adj. side multiply		To get Hyp. multiply	
	Hyp. by	Adj. side by	Hyp. by	Opp. side by	Adj. by	Opp. by
60						
45						
30						

On examination it will be seen that these six columns correspond to the six trigonometric functions in the order, sin., tan., cos., cot., sec., and csc. And at this point I tell the class that a study of these multipliers, with those for all other angles, constitute the subject of trigonometry, and that for other angles equations more complicated than the Pythagorean are needed to find the multipliers. The next work consists in adopting the standard names so that our language may be less complicated. Using a for adjacent side, b for opposite side, and h for hypotenuse, we write

$$a = h\cos A \qquad b = h\sin A \qquad b = a\tan A.$$

According to these definitions the pupil thinks of the trigonometric functions not as ratios but as multipliers. Since they are used chiefly as multipliers I can see no particular objection to these definitions; in fact, if tradition were not against it, they are really the better definitions. When reciting the definitions, the pupil says "the cosine of an angle is the multiplier used in getting

the adjacent side from the hypotenuse" etc. Only the cosine sine and tangent were used in subsequent problems, and besides the 45^0 angle only multiples of 10^0 were used.

The teacher who has always used similar triangles as a basis for introducing and defining the trigonometric functions may feel that this method is not rigorous. But is it any less rigorous than some of our other work? For example, in drawing the graph of a line we invariably use and emphasize the fact that we need plot only two points. Here the assumption is that if the coordinates of two points satisfy an equation, then the coordinates of any point on the line joining the given points will satisfy the same equation. The proof of this statement would require the use of similar triangles. Or, when we draw the graph of $y=kx$ we may regard the graph as a device for multiplying any horizontal length by a certain k. But without similar triangles we could not prove that the device works for all abscissas merely because it worked for one of them. In fact, should a pupil ever question the correctness of our trigonometric multipliers, this reference to $y=kx$ is, I believe, the best illustration to use in clearing up his doubts.

Every chapter of trigonometry contains the inevitable exercise wherein the pupil is asked to draw various angles, complete the right triangle, measure the sides and thus compute the ratios and compare the results with a table. Such work is intended to aid the pupil in remembering the definitions and would constitute about one day's assignment of homework. But as every hour becomes more precious with our attempts to complete the pupil's education in a single year, that exercise may be omitted under this plan. Moreover, by computing the functions for these three angles from equations instead of by experiment I can once more impress the pupil with the importance of the equation as the central idea in all his work. Further, when the allotted time for the study of trigonometry is ended, the fact that we discovered the multipliers from equations will serve as an excuse or motive for a return to the subject of equations again. The method of introducing trigonometry discussed in this paper applies to a ninth grade class in algebra. In a tenth grade class studying geometry the subject would naturally arise after studying similar triangles. We have then two ways of approaching trigonometry, and if both are used at their proper times we may succeed in accomplishing that much desired but rather difficult task of correlating the work of the first two years.

A NEW ELLIPSOGRAPH?

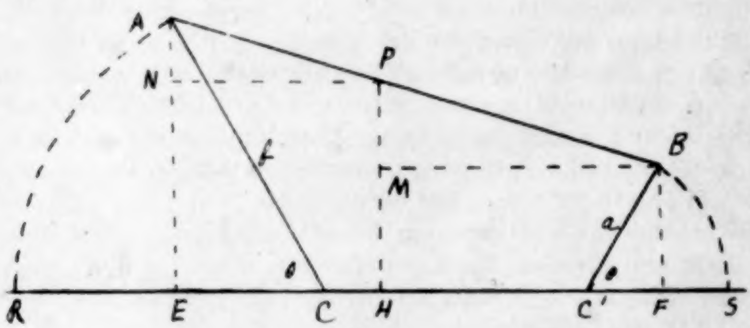
BY J. A. VAN GROOS

Corvallis, Ore.

The following locus problem was obtained by watching the opening and closing of gates at a railroad crossing a city street.

One long arm across the street and a short arm across the sidewalk. The movement of the ends of the arms suggested finding the locus of the center of the line joining the ends. Taking a sheet of polar coordinate paper, I found a curve that looked like an ellipse. I then took the general problem where the two arms were fastened at different points and took the point P, in the line joining moving ends, so that the ratio of the segments from p to the extremities was constant. The locus of P then was found to be an ellipse.

It is of interest to note that the problem indicates a method of constructing an ellipsograph, taking the arms rotating about the same point, and the point P the middle point of the line joining the moving ends.



Given two unequal arms AC and BC′ rotating in opposite directions from the positions RC and SC′ with equal angular velocities, and a point P, in AB or AB extended, so that (AP) / (PB) = λ some constant ratio. To find the locus of P.

Let $AC = b$, $BC^1 = a$, $CC^1 = d$, the origin at C. From the similar triangles NPA and PMB, we have

$$(NP)/(MB) = (AP)/(PB) = \lambda; \text{ or } (EH)/(HF) = \lambda,$$

$$\text{or } (EC+x)/[(CC^1+C^1F-x)] = \lambda$$

$$\text{or } [(b\cos\theta+x)/(d+a\cos\theta-x)] = \lambda.$$

Hence $[(x(1+\lambda)-\lambda d)]/(\lambda a-b) = \cos\theta$ (1)

Also $(AN)/(PM) = \lambda$, or $[(AE-y)]/(y-BF) = \lambda$,

$$\text{or } [(b\sin\theta-y)]/(y-b\sin\theta) = \lambda$$

Hence $[(y(1+\lambda)]/(\lambda a+b) = \sin\theta$ (2)

squaring (1) and (2), and adding

$$[(x^2(1+\lambda)^2-2x\lambda d(1+\lambda)+\lambda^2d^2)]/(\lambda a-b)^2+$$
$$[(y^2(1+\lambda)^2]/(\lambda a+b)^2 = 1$$

or $(x^2(1+\lambda)^2(\lambda a+b)^2-2x\lambda d(1+\lambda)(\lambda a+b)^2+\lambda^2d^2(\lambda a+b)^2$
$+y^2(1+\lambda)^2(\lambda a-b)^2 = (\lambda a+b)^2(\lambda a-b)^2$ (3)

This is the equation of an ellipse, for if
a = coef. of $x^2 = (1+\lambda)^2(\lambda a+b)^2$
b = coef. of $xy = 0$
c = coef. of $y^2 = (1+\lambda)^2(\lambda a-b)^2$ are placed in b^2-4ac, we find $b^2-4ac<0$, and since $a\pm c$ we have an ellipse, and locus of P is an ellipse. When $d=0$, (3) becomes
$x^2(1+\lambda)^2(\lambda a+b)^2+y^2(1+\lambda)^2(\lambda a-b)^2 = (\lambda a+b)^2(\lambda a-b)^2$
or $(x^2/[(\lambda a-b)/(1+\lambda)]^2)+(y^2/[(\lambda a+b)/(1+\lambda)]^2) = 1$ (4)

This is equation of ellipse with center at c. If in (4) we put $\lambda = 1$, that is, if p is at middle point of AB, we get
$(x^2/[(a-b)/2]^2)+(y^2/[(a+b)/2]^2) = 1$ (5)

Equation (5) corresponds to the ellipse found by means of concentric circles, but here the ellipse is shown to be generated by continuous motion.

If in (3) we put $b = 0$, we get
$x^2(1+\lambda)^2-2x\lambda d(1+\lambda)+\lambda^2d^2+y^2(1+\lambda)^2 = \lambda^2a^2$
This is equation of a circle with center $[\lambda d(1+\lambda)/(1+\lambda)^2, 0]$ that is, with center $([\lambda d]/[1+\lambda], 0)$ and radius = $(\lambda a)/(1+\lambda$. If in (3), we put $a = 0$, we get equation of circle with $([\lambda d]/[1+\lambda], 0)$ for center and radius = $b/(1+\lambda)$.

When the two arms rotate in the same direction, starting from a horizontal position, the locus of p is a circle, its equation is
$[x^2(1+\lambda)^2]/[(\lambda a+b)^2]-[2x\lambda d(1+\lambda)]/[(\lambda a+b)^2]+[\lambda^2d^2]/[(\lambda a+b)^2]+$
$[y^2(1+\lambda)^2]/[(\lambda a+b)^2] = 1$

Equation (3) could have been obtained by finding the coordinates of A and B and then using
$x = (x_1+\lambda x_2)/(1+\lambda)$, $y = (y_1+\lambda y_2)/(1+\lambda)$, where (x,y) are the coordinates of P, (x_1y_1) of A and (x_2y_2) of B.

Equation (5) gives a simple process for the construction of an ellipsograph. Two arms are made to rotate about a point. The middle point of the line joining the ends of the arms will generate an ellipse.

THE PREPARATION OF PERMANENT LANTERN SLIDE RECORDS OF CRYSTALLINE FORMS.

By Walter O. Walker

High School, Carthage, Mo.

Crystalline forms are very beautiful, and because of their beauty, appeal to the average student. However, the presentation of various crystals to classes from time to time has almost universally failed to interest them. Hence, the following method of presentation has been of considerable aid in the classroom.

The Projection of Growing Crystals

Very few actually see crystals formed because of their minute size. Because of this, an enlargement of the phenomena is desirable. In order to give this enlargement, the following plan has been perfected. An ordinary thin glass lantern slide is thoroughly cleaned and rinsed with distilled water, and dried. One-half inch gummed paper strips are pasted on the face of the plate at the outer edges of the plate. This affords a tank-like structure. The adhesive force between the solution, and the paper, is stronger than the cohesive force of the solution itself. As a result, a uniform layer of the solution is assured over the entire surface of the plate, thus eliminating the "puddling" effect so apparent on an ordinary plate.

The solutions used may be of any of the easily crystallized salts. Potassium nitrate and copper sulfate solutions are used in the following paragraph.

The concentrated solution is poured on the plate until a thin layer results. It may be rubbed over the surface of the plate with the finger in order to secure proper contact with the edges of the paper. Any foreign material which might be introduced at this time, will aid in the crystallization as a nucleus around which the crystals will form. The slide is now turned on edge, allowing the excess solution to drain off. It is next inserted in the lantern slide carriage, and projected on the screen. This gives a large field upon which to observe the ensuing crystallization. For a time, nothing appears on the screen. Then small dark spots begin to make their appearance, and about these spots, as nuclei, the crystals begin to grow. When once started, their growth is very rapid, covering the entire field and affording an interesting study on crystallization.

Preparation of Permanent Slides

In order to make the slide a permanent record, it is removed from the lantern, and the surface of the paper scraped clean from all adhering salt. Glue is then applied to the paper, and a thin glass plate (an ordinary blank lantern slide) or a sheet of mica, is placed over the face of the crystals and pressed firmly downward in contact with the glue The glue is allowed to dry under the pressure exerted by a heavy weight placed upon the lantern slide. This gives a permanent record, inasmuch as the crystals cannot be scrapped off, or damaged in any way. If desired, the joints between the glass and the paper may be made moisture proof with shellac, thus securing the safe keeping of hydroscopic crystals. When slides are to be made in large numbers, the above directions may be followed, except that the slides, after draining off the excess solution, should be laid flat on a table during crystallization.

Using the above method, slides have been prepared of the following:

Copper Sulfate.
Alum.
Potassium Nitrate.
Rhombic Sulphur.
Nickle Ammonium Sulfate.
Ammonium Chloride.
Sodium Chloride.
Sodium Nitrate.
Manganese Chloride.
Ammonium Nitrate.
Ammonium Sulfate.

A modification of the above, to use alcohol as a solvent, instead of water, will render available for the preparation of permanent records, substances which are only soluble in alcohol. Crystals of iodine can best be formed by subliming the iodine and allowing it to condense on the cold surface of a slide.

Crystals which are very small may be projected microscopically. Their growth may also be studied in this same fashion.

If the above solutions are in thin layers the result will be crystals of a featherlike form, and practically plane. By increasing the depth of the solution, the crystals may be changed from the plane to the solid form. In this way, a second set of slides of the compounds used previously, may be prepared. This will set forth a very interesting comparison regarding crystals as affected by the conditions surrounding their formation.

A set of slides of this nature can be prepared and kept for years, and will offer very interesting lecture material. The use of slides in this connection might be of practical value in crystallography.

MALABAR.

"Malabar perhaps means but little to the average western ear, but as 'the land of the Moplahs' it has recently been in the forefront of the news of the day," says a bulletin issued from the Washington, D. C., headquarters of the National Geographic Society.

"It is in Malabar—a narrow strip of the western coast of India—that those fierce, fanatical Mohammedans are carrying on a warfare reminiscent of the turbulent outbreaks of the Arabian Moslems in the early and bloodier days of their religion.

"Malabar is in the strange position of being almost the closest part of India to the people of the Western World, and yet farthest from their knowledge. Most of the commerce and most of the travel to India go north of Malabar to Bombay or around the point of the peninsula to Madras and Calcutta, India's 'backdoors.' And so Malabar has slumbered between the sea and the mountains which hem it in on the landward side, has felt comparatively little of the influence of Europe, and has been preserved as a sort of exhibit of the India of olden times.

Typifies Ancient India.

"Physically, Malabar is the India of traditions and dreams—a warm country of quiet backwaters, of luxuriant vegetation, of crocodiles, tigers, leopards and wild elephants. And its swarming brown natives, most of them bare above the waist, give a final conventional Eastern touch. The country is a narrow coastal plain 150 miles in length from north to south, fronting on the Arabian Sea on the Europeward side of India, and backed by the Western Ghats, 3,000 to 8,000 feet high and from 20 to 60 miles from the coast. The only break in the mountain wall is at Palghat Gap, 16 miles wide, through which a railway enters the otherwise isolated region.

"The many rivers which rush down the mountains under the stimulus of the ten feet of rain which falls annually, carry much sediment and have built up islands and sands pits which form a network of lagoons and backwaters along much of the coast. Many of these are connected by canals, the system forming an important feature in the communications of the region. The islands and spits are thickly planted with cocoanut palms as are the inland margins of the lagoons, and the graceful groves give a characteristic appearance to the region.

Wild Elephants Roam.

"Farther inland, on the narrow ribbon of level ground are irrigated rice fields. The foothills are veritable garden plots and were cultivated with equal care in 1498 when Vasco da Gama, fresh from his famous voyage around the south of Africa, anchored off the coast. The uplands are covered with heavy forests both evergreen and deciduous, with their undergrowth of tree ferns and rhododendrons, and their delicate and colorful orchids. In these mountain forests roam herds of wild elephants. Malabar and Travancore to the south are now the elephant country of India, par excellence. Seaward the uplands are broken into precipitous peaks with dark green ravines in which silver streams descend in numerous waterfalls, all uniting to form scenes of unrivaled beauty. Malabar is the most beautiful, the most fertile, and the richest district of the Madras Presidency.

"Though the Malabar coast is blessed with rich soil and luxuriant vegetation it is not as dependent on agriculture as most other portions of India. Fish abound in the sea and are caught in great quantities and eaten. The timber industry, too, is important and many natives are employed in it. Famines are practically unknown in this favored corner of India.

Religious Cause Conflicts.

"With Nature so bountiful it might be supposed that there would be general prosperity and peace in Malabar. Prosperity is fairly well distributed but the motley of religions makes peace more difficult; and every now and then it brings about a turbulence that is unknown these days in other parts of India. The fierce fanaticism of the Mohammedan Moplahs and the stories of their bloody and furious outbreaks which reach the outside world may lead to the belief that this is as much a Mohammedan land as Arabia or Persia. The truth is that barely 30 per cent of the population are followers of the Prophet while about 68 per cent are votaries of Hinduism and some 2 per cent are Christians.

"In prestige the Hindus are much the most important. The Nambudri Brahmans, at the very top of the caste scale, number only 20,000 in the total population of 3,000,000 of the Malabar District, but are looked up to with the greatest reverence. Nearly all of them are landholders, many of very large estates. They hold aloof from public affairs and scorn modern education, holding more tenaciously, probably than their fellow religionists in any other part of India, to the ancient customs of their faith.

Caste Strictly Observed.

"The old conception of ceremonial pollution is a living thing in Malabar and is strictly adhered to except in the cities. There are varying distances within which the mere presence of a member of a lower caste is supposed to defile the Brahman. A high caste man returning from his cleansing bath shouts out that he is approaching, and the low caste members humbly retire to the roadside or into the fields until he has passed. Even many Mohammedans follow this custom lest economic pressure be brought to bear through boycotts or other means to destroy their livelihood.

"The unusually troublesome role which the Moplahs play in Malabar is due to the fact that these Mohammedans are strikingly different from the other Moslems of India. Mohammedanism in the greater part of India has been colored and tempered by the milder Hinduism; many of the Indian followers of Mohammed, in fact, are merely converted Hindus or their descendants. Many of the Malabar Moslems, however, are the descendants of the large numbers of Arab traders who went to the west coast many centuries ago and they have inherited all the fierceness and fanaticism of the Mohammedans of the Arabian deserts.

"In a community where the Hindus outnumber them more than two to one, and where the most powerful and most respected members of society are of the opposing religion, the Molpahs live for considerable periods in peace. But suddenly some incident is seized upon—like the killing of a Hindu landlord, the defiling of a Hindu temple, or the looting of a house—and a new outbreak occurs. The fanaticism of the Moplahs under such circumstances is hardly to be exaggerated. Groups go out with the definite idea of making martyrs of themselves. They are consecrated according to their religion and are hardly known to surrender. Instead they sell their lives as dearly as possible. In some instances bands, entrenched in structures from which they shot all comers, have been dislodged only by the use of dynamite.

IMPORTANCE OF EYE CARE—MOST EYES DEFECTIVE.

Statistics covering many years, show that nine out of every ten persons over 21 usually have imperfect sight. At 31 the proportion is larger. Above 40 it is almost impossible to find a man or woman with perfect sight. For the last 100 years the profession has wrestled in vain with the problem, finding no means compatible with the conditions of modern life

for preventing errors of refraction, and no means of relieving them except by eyeglasses.

It was learned some years ago by the examination of several thousand school children in one of our large cities that 66% of them had defective vision of such a degree as to warrant the wearing of glasses.

Quite recently the examination of more than ten thousand employees in factories and commercial houses showed that 53% had uncorrected faulty vision, 13% had defects which were corrected making a total of 66% with defective eyes.

These two surveys were made under different auspices several years apart. The figures are startling. They mean that a very large majority of the public have eyes defective to such a degree as to require glasses to conserve vision and make the individual a happier and more efficient member of society.

Our eyes are large factors in our efficiency. Nature allots each organ of the human machine a certain portion of nerve energy. When eyes that are defective demand more than their share of this nerve energy it must, of necessity, lessen the normal supply. The wasting of nerve energy directly diminishes human efficiency. Often the victim of defective eyes is unaware of trouble. It may be indicated by headaches, often attributed to stomach trouble, by nervousness, drowsiness and irritability.

TEST PAPERS IN CHEMISTRY.

The four test papers which follow have been used by Mr. Charles H. Stone, English High School, Boston, Mass., in some of his chemistry classes. They cover the chapter on nitrogen compounds. The four papers were all given to one class, but so distributed that no two pupils occupying adjacent seats had the same set of questions. If the questions are good ones, let Mr. Stone know about it.

C 4. Test 5A-A. Star Series.

1. Define: calorie, normal salt, basic oxide, "ite" salt, atom.
2. By what tests may ammonium nitrate be identified? Write equation for one of the tests. What are "nitrates"?
3. How many grams nitric acid can be made from 50 g. sodium nitrate? Are two answers possible? Explain why.
4. Discuss the action of DILUTE and CONCENTRATED nitric acid, on zinc, using equations.
5. How is nitrous oxide made? Equation? Properties of N_2O?
6. Find anhydrides of the following: nitric, phosphoric, sulphuric, carbonic acids. Show how each result is obtained. What are acid anhydrides?
7. Give three ways with equations, to make nitrogen dioxide.
8. Write equations for: barium nitrate plus heat, ammonia gas plus sulphuric acid, calcium oxide plus water, nitrous acid plus sodium hydroxide.

C 4. Test 5 A-B. Star Series.

1. Define: radical, hydroxide, strong acid, nitrate, ammonium.
2. Give properties and uses of ammonia gas. Compare its action on hot and cold water. Equation? What are "nitrites"?
3. How many grams ammonia gas needed to neutralize 21 grams nitric acid? What weight of the salt will be formed?
4. Discuss effect of heat on different nitrates; write all equations. Test for NH_4 salts?
5. How is nitric oxide made? Equation? Properties of NO?

6. Find basic oxide for each of the following: calcium, sodium, aluminum, potassium hydroxides. Show how each result is found. What are basic oxides?

7. Discuss fully the preparation of nitric acid; all equations.

8. Write equations for: copper oxide plus nitric acid, ammonia gas plus hydrogen chloride, ammonium nitrite plus heat, phosphorus pentoxide plus water.

C 4. Test 5 A-C. Star Series.

1. Define: ammonium, indicator, ionization, alkali, strong base.

2. Give general rule for making acids. Write three equations for making nitric acid.

3. How many liters ammonia gas can be made from 61 g. ammonium sulphate? 1 l. ammonia is .76 g.

4. Build up equation for action of nitric acid on copper. Equations for action on Ag and Pe.

5. Give two ways, with equations, for making nitrogen dioxide. Give properties of this gas.

6. What are acid anhydrides? Name and formula for product obtained when oxides of phosphorus, carbon, sulphur, chromium (CrO_3) dissolve in water. Show how each result is found.

7. How is nitrous oxide made? Equation? Give properties. Is N_2O a stable compound? Why?

8. Write equations for: lead oxide plus nitric acid, barium oxide plus water, ammonia gas plus nitric acid, nitrous oxide plus hot copper.

C 4. Test 5 A-D. Star Series.

1. Define: anhydride, "ate" salt, base, dibasic acid, acid salt.

2. Give general rule for making ammonia gas. Write three equations for making ammonia gas.

3. How many grams sulphuric acid needed to make 21 g. nitric acid? Are two answers possible? Why?

4. Why use sulphuric acid when making nitric acid? Why use heat? Why is the nitric acid yellow?

5. How would you tell NO from N_2O? Equation for making each? Which supports combustion better? Why?

6. What are basic oxides? Name and formula for product obtained when oxides of sodium, calcium, potassium, magnesium, dissolve in water. Show how each result is obtained.

7. Discuss effect, with equations, of heat on nitrates of metals. Give properties of ammonia gas.

8. Write equations for: ammonia gas plus hot copper oxide, copper carbonate plus nitric acid, phosphorus pentoxide plus water, ammonium nitrite plus heat.

THE NATIONAL COUNCIL OF MATHEMATICS TEACHERS.

The National Council of Mathematics Teachers held its annual meeting at Chicago on March 1, 1922, in connection with the meeting of the Department of Superintendence of the National Education Association. At the business session in the morning, matters of policy for the development of the National Council were discussed, and these matters were set forth by President Minnick at the dinner in the evening. It seems logical and desirable that the Council should in a sense continue the work of the National Committee on Mathematical Requirements, which is about to complete its formal work. For this purpose, as well as for many other

reasons, it is desirable that the National Council should double, or even quadruple, its present membership of twenty-seven hundred, and a campaign for that purpose will be undertaken at once.

At the afternoon session, Dr. J. M. Kinney, of Chicago, gave a paper on "The Function Concept in High School Mathematics." Professor H. E. Slaught, of Chicago, discussed the question of "Elective Courses in Senior High School Mathematics," in place of Professor E. R. Hedrick, who was unable to be present. Professor J. W. Young, of Dartmouth College, gave a report on "Some Phases of the Work of the National Committee"; and Mr. Alfred Davis, of St. Louis, discussed "Unsettled Problems Concerning the Teaching of Secondary Mathematics." At the evening meeting following the dinner, at which over two hundred members were present, Professor H. E. Slaught presided. The speakers were Mr. W. D. Reeve, of the University High School, Minneapolis, who spoke on "The Case for General Mathematics"; Professor G. W. Myers, of Chicago, on "Reaction Versus Radicalism in Teaching Secondary Mathematics"; Mr. Raleigh Schorling, of the Lincoln School, New York, on the question "Is the Teaching of Mathematics Responding to Modern Demands in Secondary Education?"; and President J. H. Minnick on "A Program for the National Council of Teachers of Mathematics."

It was universally agreed that this was the most successful meeting of the National Council which has been held.

WHAT IS THE BEST PRINTING-PROCESS?

This is a question that is old and, yet, ever new. Camera-club members in all parts of the world have their ideas and their own experiences to relate in support of their favorite printing-process. To say the least, the discussions are usually very interesting, if not always convincing. In hearing and reading of these friendly discussions, we have noted that the bromoil process is very popular with a number of well-known photo-pictorialists. For a time, it was difficult to obtain the necessary supplies; but we are glad to call attention to the complete stock of Bromoil Paper and supplies now to be had from Ralph Harris and Company. This firm, it will be recalled, is the sole American agent for the famous Wellington products. Those who wish to make bromoils may now obtain the necessary materials and instructions; and thus prove to their own satisfaction whether or not the bromoil process is what some workers claim it to be—the best printing-process.—*Photo-Era.*

NOTABLE LECTURES AT THE RYERSON PHYSICAL LABORATORY OF THE UNIVERSITY OF CHICAGO.

Announcement is just made from the University of Chicago that one of the leading mathematical physicists of the world, H. A. Lorentz, Professor of Physics in the University of Leiden, will lecture at the Ryerson Physical Laboratory on March 17 and 18 on "The Constitution of Matter." On April 3 also Professor Lorentz will lecture on "Theory of Spectral Lines" and April 4 on "Theory of Relativity."

It is also announced that the following graduate courses in theoretical physics will be given during the coming Summer Quarter at the University of Chicago: "The Electrical Properties of Gases," by Professor H. A. Wilson, of Rice Institute, Texas; "Thermodynamics, Radiation, and the Quantum Theory," by Professor W. F. G. Swann, of the University of Minnesota; and "Relativity and the Electron Theory," by Assistant Professor Leigh Page, of Yale University.

PROBLEM DEPARTMENT.

CONDUCTED BY J. A. NYBERG,
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

LATE SOLUTIONS.

727. *E. B. Escott, Oak Park, Ill.*

SOLUTION OF PROBLEMS.

731. *Proposed by J. F. Howard, San Antonio, Texas.*

A geometric and an arithmetic progression have the same pth, qth, and rth terms, a, b, and c, respectively. Prove

$$a(b-c)\log a+b(c-a)\log b+c(a-b)\log c = 0.$$

Solution by T. E. N Eaton, Redlands H. S., Cal.

If d is the constant difference in the A. P., and x is the ratio in the G. P., then

(1) $b-a = (q-p)d$ $\qquad c-b = (r-q)d$ $\qquad$ and

(2) $b/a = x^{q-p}$ $\qquad c/b = x^{r-q}$

From (1): $(b-a)/(q-p) = (c-b)/(r-q)$.

From (2): $(r-q)(\log b-\log a) = (q-p)(\log c-\log b)$

and from these equations, we get

$(b-c)\log a+(c-a)\log b+(a-b)\log c = 0$.

Hence the proposed equation is untrue unless a, b, c are identical terms.

Also solved by Moe Buchman, New York; Michael Goldberg, Philadelphia, Pa.; and E. Tabor, Upper Lake, Cal. It is incorrect to assume, as some solutions did, that $c-b = b-a$ for this implies that the qth term is halfway between the pth and the rth. This was done in the solution for problem 713 in the January copy, as various readers have pointed out.

732. *Proposed by Elmer Schuyler, Bay Ridge H. S., Brooklyn, N. Y.*

BCA is a diameter, CA = CB = 1. Draw the semicircle AGB, G being its midpoint. With A as a center, and AG for a radius, draw an arc cutting AB in D. With A as a center, and AC as a radius, draw an arc cutting the semicircle in M. Show that DM is approximately $\sqrt[3]{2}$.

(*Peraux's approximation.*)

I. *Solution by R. H. Shanks, Culver Military Academy, Culver, Ind.*

GA = $\sqrt{2}$. DC = $\sqrt{2}-1$. CE, the projection of CM on CA, equals 1/2. Hence, either from the law of cosines for $\triangle$ DCM, or from the right $\triangle$ DEM, DM^2 = $3-\sqrt{2}$. $\therefore$ DM = 1.2592+ but $\sqrt[3]{2}$ = 1.2599.

II. *Comment by Walter C. Eells, Whitman College, Walla Walla, Wash.*

This is the third approximate construction for $\sqrt[3]{2}$ presented in this department. While it excells the other two in simplicity of construction and proof, it is decidedly inferior to either of them in accuracy. In problem 702 the error was .00015, and in problem 727 it was .0000116, and in this problem it is .00064.

Also solved by Moe Buchman; J. F. Howard, San Antonio, Tex.; E. Tabor; Smith D. Turner, Andover, Mass.; and H. L. Wood, Boonton, N. J. Inasmuch as all the previous approximations have resulted in values which are smaller than the correct value, one more approximation is proposed in problem 747 which gives a result larger than the correct value.

733. *Proposed by Harris F. MacNeish, College of the City of New York.*

Find without using trigonometry the volume of a regular dodecahedron in terms of the edge e.

I. *Solution by Norman Anning, Ann Arbor, Mich.*

If e is the side of a regular pentagon and d, the diagonal,

$$(d-e)/e = e/d,$$
$$d^2-ed = e^2,$$
$$2d = e(\sqrt{5}+1).$$

The dodecahedron of edge e can be made by taking a cube of edge d and applying to each face a "cottage roof." Example: ABCD is a face of the cube and points E and F are taken outside of the cube, such that

$$AE = BF = CF = DE = EF = e,$$
$$AF = BE = CE = DF = AB = d.$$

If h is the distance of the ridge pole EF from the plane ABCD,

$$(2h)^2+d^2+(d-e)^2 = (2e)^2,$$
$$(2h)^2 = e^2,$$
$$2h = e.$$

By the prismoid formula, the volume, v, of the solid ABCDEF is

$$v = h[d^2+d(d+e)+0]/6.$$

The volume, V, of the dodecahedron $= d^3+6v = d^3+e(2d^2+ed)/2.$

$$2V = 2d^3+2d^2e+e^2d = 3d^3+d^2e.$$
$$16V = 3(2d)^3+2(2d)^2e = e^3(60+28\sqrt{5}).$$
$$V = e^3(7.663).$$

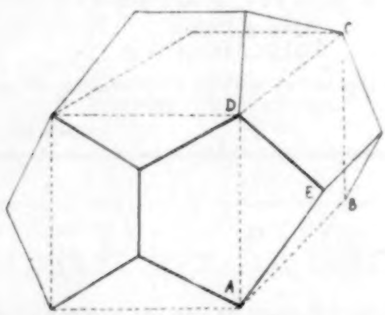
II. *Solution by E. Tabor, Upper Lake, Cal.*

If a is the apothem of a regular pentagon of side e, then

$a = e[(5+2\sqrt{5})/20]^{1/2}$; and the area is $5ae^2/2$.

If a line is divided into mean and extreme ratio, the whole line and the greater segment are the length of the edge of a cube and of a dodecahedron which can be inscribed in the same sphere. Hence the diagonals of a cube and dodecahedron, and the diameter of the sphere are the same. Then if the edge of the dodecahedron is e, the edge of the cube is $e(1+\sqrt{5})/2$ and the diagonals are $e\sqrt{3}(1+\sqrt{5})/2$. To find the apothem, h, of the dodecahedron we use the right triangle of which the apothem is one side, the radius of the sphere is the hypotenuse, and the other side is the radius of the circle circumscribing a face of the dodecahedron.

$$h = \tfrac{3}{4}\left(\frac{1+\sqrt{5}}{2}\right)^2 e^2 - e^2\left(\frac{5+\sqrt{5}}{10}\right) = e^2\left(\frac{25+11\sqrt{5}}{40}\right)$$



The desired volume equals 12 pyramids whose bases are the faces and whose height is h. Hence it is $e^3\ (15+7\sqrt{5})/4$.

Also solved by Michael Goldberg, J. F. Howard, R. H. Shanks (2 solutions), *and E. Tabor* (4 solutions). Instead of using the prismoid formula in the first solution, the volume of ABCDEF may also be found by dividing it in three pieces by planes through E and through F, parallel to AD and perpendicular to the plane AC. In the second method the chief difficulty is in finding the height of the pyramid.

734. *Proposed by Norman Anning, Ann Arbor, Mich.*

If a, b, c are the roots of $x^3+x^2-2x-1 = 0$, show that $a^2b+b^2c+c^2a$ equals either 3 or -4.

Solution by John B. Faught, Yankton College, So. Dakota.

Let $A = a^2b+b^2c+c^2a$, and $B = ab^2+bc^2+ca^2$. Also, we know $\sqrt{a+b+c} = -1$, $ab+bc+ca = -2$, $abc = 1$. Then

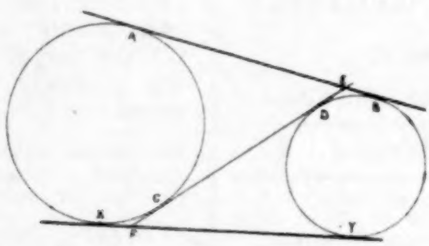
$A+B = (a+b+c)(ab+bc+ca)-3abc = -1$, and

$A \cdot B = a^3b^3+b^3c^3+c^3a^3+abc(a^3+b^3+c^3)+3a^2b^2c^2$. But
$a^3b^3+b^3c^3+c^3a^3 = (ab+bc+ca)^3-3abc(A+B)-6a^2b^2c^2 = -11$ and
$a^3+b^3+c^3 = (a+b+c)^3-3(A+B)-6abc = -4$. Hence $A \cdot B = -12$.
Therefore A and B are the roots of the quadratic equation $y^2+y-12 = 0$, whose roots are 3 and -4. Hence A, or $a^2b+b^2c+c^2a$ equals either 3 or -4.

Also solved by Moe Buchman, J. F. Howard, and the Proposer, who adds that the roots of the given cubic are $\omega+\omega^6$, $\omega^2+\omega^5$, and $\omega^3+\omega^4$, where $\omega^7 = 1$, but $\omega \neq 1$.

735. *For high school students. Proposed by the Editor.*

Prove: the two common external tangents of two circles intercept on a common internal tangent a segment, CD, equal to the external tangent AB.



Solution by Dolpha Smith, North East H. S., Kansas City, Mo.

Given: two external tangents AB and XY; internal tangent CD, extended to F and E.

To Prove: EF = XY or AB.

Proof:	CF = XF	Tangents from an external point are equal.
	ED = EB	
	AE = EC	
	FY = FD	
	XY = AB	Common external tangents are equal.
(1)	AB − EB = CD + DE	Common external tangents are equal.
(2)	XY − XF = CD + CF	Common external tangents are equal.
(3)	2XY − XF − EB = 2CD + CF + ED	Adding (1) and (2)
(4)	2XY = 2CD + CF + XF + ED + EB	Composing
(5)	2XY = 2CD + 2CF + 2ED	Substitute equals for equals
(6)	XY = CD + CF + ED	Divide (5) by 2.
(7)	XY = FE	Adding.

The next best solutions were by *Wm. Davis, Salida, Col., Hugh Jantzen, Colton, Cal.,* and *Alice Lee Smith, Kansas City, Mo.* Other solutions were: from *Colton, Cal., James Ahrens;* from *North East H. S., Kans. City, Mo., Margaret Miller, Richard Lewis;* from *Mattoon, Ill., Geo. Maischaider;* from *Redlands, Cal., Frank B. Frye, Horner Joy, Wadsworth E. Pohl, Eva Tilton;* from *Salida, Col., Ben Shaw.* The editor feels that the pupils are satisfied to find *a* solution and do not put enough thought into making the solution *better* after it has been found. To illustrate this fact, the following proof of the exercise is shown:

FC = XF	Tangents from an external point are equal.
FD = FY	
CE = AE	
DE = EB	
FC + FD + CE + DE = XF + FY + AE + EB	Adding.
FE + FE = XY + AB	Combining as shown.
2FE = 2XY	Since AB + XY.
FE = XY	Dividing by 2.

Some of the things to be noticed here are: If FC and CE are to be added, do not write the parts as FC and EC, nor as CF and CE, nor as CF and EC, as this necessitates skipping about in the picture. The first four

equations should not be written in *any* order, but written so that the parts which afterwards combine will appear as near each other as possible. The line is drawn to show addition just as we do in arithmetic when adding a column of numbers. The lines in the fifth equation which show what terms are to be combined are as useful as the lines on a road map. It may seem out of place to write AB = XY in the column reserved for reasons, but this does make the work easier to understand. A good exercise to try next is that of proving FC = DE with a minimum number of digressions.

PROBLEMS FOR SOLUTION.

746. *Proposed by J. David Weintraub, Newport, Ky.*

AB is the diameter of a circle; C and D are its trisection points in the order A, C, D, B. E and F are points on the circle such that arc BE = arc BF = 60°. Prove that the circle drawn through E, D, and F trisects the minor arcs of all the circles which have AB as a chord.

747. *Proposed by Elmer Schuyler, Bay Ridge H. S., Brooklyn, N. Y.*

Let AB = 1. Extend AB to C making BC = side of a regular decagon inscribed in a circle of unit radius. On AC as a diameter, draw a semicircle, and let the perpendicular to AC at B intersect it at D. Show that 2(BC+AD)/3 is approximately $\sqrt[3]{2}$. (*Boccali's* method.)

748. *Proposed by Norman Anning, Ann Arbor, Mich.*

Show that, excluding trivial cases there are 62 polynomials with integral coefficients by which $x^{12}-1$ may be divided without remainder.

749. *Proposed by J. A. van Groos, Oregon Agricultural College, Corvallis, Ore.*

Without trigonometry prove that the area of a triangle of sides a, b, and c is $abc/4R$, where R is the radius of the circumscribed circle.

750. *For high school students. Proposed by the Editor.*

In a 10 mile race, A can beat B by 2 miles, and A can beat C by 4 miles. By how many miles can B beat C?

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 *Wilbur Ave., Cleveland, Ohio.*

Examination and Test Papers.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

QUESTIONS.

393. *Proposed by H. E. Brown, Technical Dept., W. M. Welch Scientific Co., Chicago, Ill.*

Arrange R_1, R_2, R_3 and R_4 so that V_1 will be from 6 to 12 volts on opening the push, and so that, when the push is closed, one can get from 1/10 to 1/4 amperes through the bell which has a resistance of, say, 2 ohms.

Fix V_1, or amperage, through the bell, and solve so as to get definite values for all other quantities.

394. *Submitted by D. G. Sequist, Benton High School, St. Joseph, Mo.*

How do you like the following examination in General Science?

How much time should be given to answer it?

How should it be graded?

GENERAL SCIENCE 2. FINAL EXAMINATION, 1921.

The First Year of Science, John C. Hessler, Pages 174-337.

1. Power times .... equals .... times ....
2. In a lever of the first class, we place the .... between the .... and the ....

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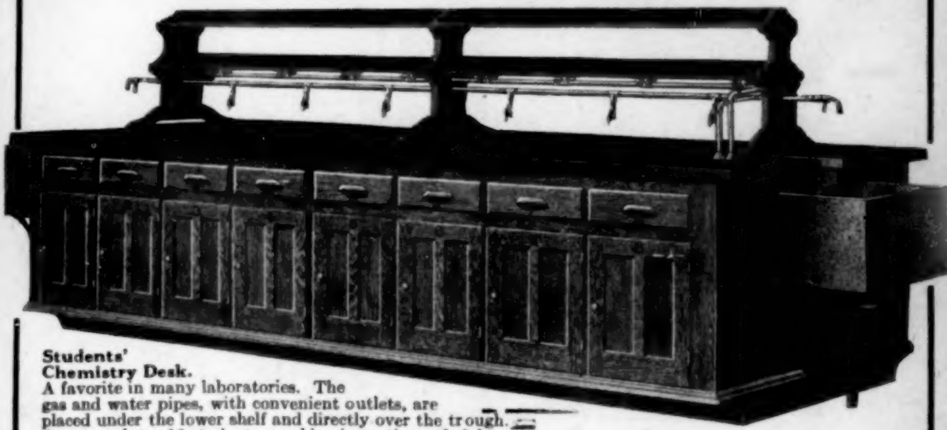

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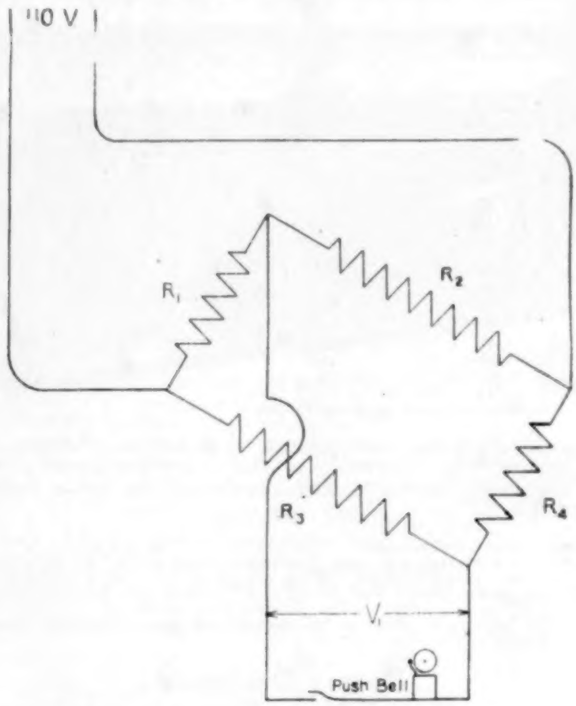
3. We have no advantage with .... pulley but with .... pulleys we can raise 2 pounds with a 1-pound effort.
4. We cannot get as much work out of a machine as we put in it because of ....
5. An acid always contains the element .... and turns litmus ....
6. Most acids when put with metals give off .... and when added to carbonates they release ....



7. Bases turn litmus .... and react with acids to form ....
8. Soaps are .... of ....
9. Hardness of water is its ....
10. Cotton will dissolve in .... wool and silk in ....
11. Substances used to unite the dye to the cloth are called ....
12. A trap prevents .... from .... into the house.
13. In the Bunsen burner .... is mixed with the .... before it is burned.
14. The .... stove is better than .... but it is more ....
15. An instrument to regulate the temperature is called ....
16. The greatest need of ventilation is .... of the air.
17. Artifical heating must be accompanied with the addition of .... as the amount of .... is sure to be too ....
18. Glass is made of a mixture of .... and ....
19 To increase the efficiency of gas lights we use a ....
20. Gas is measured in .... and electricity in ....
21. Properties of .... and .... cause weather.
22. Average of weather conditions is the ....
23. Changes in density of air are brought about by .... and by addition of ....

24. .... does not fall but is ....
25. The temperature to which air must be cooled to form dew is called the .... and if below freezing we have ....
26. Rainfall is less in the .... and more in the .... and on ....
27. Winds blow because of .... and from a region of .... to a ....
28. .... are larger than .... or twisters.
29. Isobars are .... on the map to show points of equal .... Isotherms of equal ....
30. The crust of the earth is made of .... and .... rock.
31. Igneous rocks are formed by .... and sedimentary by ....
32. Action of air and water upon rocks is called .... and consists of .... and ....
33. Total effects of weathering is called ....
34. The foundation of soil is ....
35. Alluvial soil is .... soil. Glacial soil is formed from ....
36. The first letter of the names of the 10 elements necessary for plants to live are ....
37. Rotation means .... the crops.
38. In fertilizing the three following elements need to be supplied: ...., ... and ....
39. The object of plants is to .... and ....
40. A seed contains a ....
41. The expanded part of the leaf is the .... and the stalk is the ....
42. Plants containing .... make starch.
43. The green outer part of a flower is the .... The colored part is the .... and inside are found the .... and the ....
44. The .... are simpler than the ....
45. The .... have seeds on the .... while .... have the seed in the ....
46. The simplest animal is the ....
47. The head first appeared in the .... and the gills in the ....
48. The body of the crustaceans is made of .... and has .... that are jointed.
49. All animals below fishes are .... and all above are ....
50. The greatest care to the young is shown in the ....
51. The division of labor among the cells began in the .... and reached its climax in the ....
52. We see the change in gill structure best in the ....

Name ....

Rating ....

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for February, Joliet, Ill., $1.50 *per year*, 40 *cents a copy*. "Old Garden Flowers, Flora of the Michigan Sand Dunes," Mary E. Hardy; "The Tuille Mountain of North Dakota," O. A. Stevens; "Botany for Beginners," Willard N. Clute; "Flora of the Navajo Indian Reservation II," Owen Nelson; "Plate Names and their Meanings X, Leguminosae II," Willard N. Clute.

Americans Journal of Botany, for February, *Brooklyn Botanic Garden*, $6.00 *per year*, 75 *cents a copy*. "The growth of field corn as affected by iron and aluminum salts," Charles Homer Arndt; "Control of the sexual state in Arisaema triphyllum and Arisaema Dracontium," John H. Schaffner; "A demonstration of numerous distinct strains within the

nominal species Pestalozzia Guepini Desm," Carl D. La Rue and H. H. Bartlett.

Condor, for January-February; 770 *South Pasadena Ave., Pasadena, Calif.*, $2.25 *per year*, 40 *cents a copy*. "The Reddish Egrets of Cameron County, Tex.," J. P. Pemberton; "Magpies versus Live tock," S. S. Berry; "Notes on the Dipper in Yellowstone National Park," M. P. Skinner; "Some Birds of Roosevelt Lake, Arizona," H. H. T. Jackson.

Education, for March, *Boston, Mass.*, $4.00 *per year* 40 *cents a copy* "Moral Education in the Public Schools," Susan W. Norton; "A Project in Geography," Helen K. Brett; "Developing Leadership as a Part of Vocational Training," Olive Nolan; "Sex Education in Public Schools," By a Teacher.

Journal of Geography, for March, 2249 *Calumet Ave., Chicago*, $2.00 *per year*, 25 *cents a copy*. "Geography and World Relations," Wallace W. Atwood; "Fundamentals in Foreign Trade Education," J. Anton De Haas; "Modern Geography—From a Canadian Teacher's Point of View," A. D'Arcy Chapman; "An Atlas of France—A Project in Grade VI," Naomi M. Caldwell; "The Teaching of Place Geography," Rachel E. Day.

National Geographic Magazine, for April, *Washington, D. C.*, $3.50 *per year*, 50 *cents a copy*. "Viscount Bryce's Last Article on the United States—The Scenery of North America," 45 illustrations, including 16 special engravings; "Modern Scenes in Mesopotamia, the Cradle of Civilization," 16 illustrations in full color by Eric K. Burke; "South Georgia, An Outpost of the Antarctic," 43 illustrations, Robert C. Murphy.

Nature-Study Review, for January-February; *Ithaca, New York*, $1.50 *per year*, 15 *cents a copy*. "Sky Phenomena," W. H. Tuke; "Nature-Study of the Farm," J. D. Detwiler; "Children's Nature Interests," E. L. Palmer; "Algonquin Days," Frank Morris; "The Architecture of the Cocoa Palm," E. E. Barker; "The Appeal of the Bird to the Child," Laura B. Durand.

Photo-Era, for January, *Boston, Mass.*, $2.50 *per year*, 25 *cents a copy*. "With the Patriots at Valley Forge," Philip and Leora Wallace; "Architectural Traditions for the Photographer," Edward L. Harrison; "Winter Sport and Photography in Switzerland," Coine Codby; "Preparing Light Sensitive Photographic Paper," Chas. E. Mullin.

Popular Astronomy, for April; *Northfield, Minn*; $4.00 *per year*, 50 *cents a copy*. "Shall We Accept Relativity?" William H. Pickering; "Demonstration Apparatus in Descriptive Astronomy," Dinsmore Alter; "How to Know the Heavens," Gilbert P. Chase; "The Duration of Sunrise and Sunset," Willard J. Fisher; "A Letter of John Kepler," Florian Cajori; "Planetary Configurations," Frederic R. Honey; "Effect of the Sun-Spots on the Terrestrial Temperature," P. G. Searles; "Hypothesis on the Formation of New Stars," Alexandre Verronnet.

Scientific Monthly, for April, *Garrison, N. Y.*, $5.00 *per year*, 50 *cents a copy*. "Mental and Physical Correspondence in Twins," Dr. Arnold Gesell; "Dehydration and the Preservation of Foods," Dr. Heber W. Youngken; "A Perpetual Submarine War," R. E. Coker; "The Negro Enumeration of 1920," Le Verne Beales; "Aeronautic Accidents of two Years Compared," Dr. Ford A. Carpenter; "Why the Movies Move," Donald A. Laird; "The Sub-Conscious—What Is It?" Professor A. T. Poffenberger; "Disease and Injury Among Fossil Men and the Beginnings of Surgery," Professor Roy L. Moodie.

A HIGH SCHOOL BOY'S LETTER.

School Science and Mathematics,
5514 Cornell Avenue,
Chicago, Ill.

Gentlemen:

I recently subscribed to your publication, School Science and Mathematics; an act which I do not regret. I am a student in the Middleton, N. Y., High School, and as you can easily see, the publication is very valuable to me in my school work. Some time ago, one of my teachers said, in addressing my class, that scholars were queer folks, but I wish to add to that statement and say that some teachers are queer folks. What I'm hitting at is this:

Teachers who instruct in the very subjects in which you deal, take no periodical of any kind which deals with their work. They should take this publication just as much as the printer takes his, the doctor his, and the merchant his. Certainly the school could afford your reasonable fee. At any rate the mathematics teachers don't take a magazine of this sort, but I do, and I'm mighty glad I do. When some question is discussed in class, and I offer my reasons or suggestions, some one pops, "Where did you get your information?" Sure enough, I have a source of information.

Well! I've said enough, but I think that I have put this thought across, that your magazine is just what I have been looking for.

Wishing you future success, and with the season's best greetings, I am,

Most respectfully yours,

LEROY W. VAN KLEECK.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

Announcement of the Seventy-Seventh Meeting.

A meeting will be held at the Moses Brown School, Providence, Rhode Island, on Saturday, May 6. The program consists of a teaching lesson on "Sulphur Dioxide" by Charles H. Stone of the English High School, Boston, a talk on "Gas Manufacture" by Mr. John R. Freeman, of Providence, a lecture table demonstration of some new experiments in chemistry by Professor Herbert F. Davison of Brown University, and an address on the work of the Carnegie Laboratory of Research on Nutrition by its director, Dr. Francis Gano Benedict.

The Seventy-Eighth meeting of the Association will be held at New Haven on May 13. The program, which has not been completed at the time this issue goes to press, will be given in the June issue.

The Report of the Seventy-Sixth Meeting.

The third regional meeting of the Western Division was attended by forty members from Western Massachusetts and Connecticut, including representatives of the chemical faculties of the colleges in this region,—Amherst College, Amherst Agricultural College, Williams College Trinity, Wesleyan and Smith. Professor Joseph S. Chamberlain of Massachusetts Agricultural College gave the principal address, on "Vitamins," taking the place of Professor Carr of Mount Holyoke who was unable to speak as announced. Professor Charles Ruglas Hoover gave a current events report on the "Relation of Chemistry to the Disarmament Conference" and reports were given by Miss Alice Kennedy of the Windsor High School and Mr. Harry Wessels of the Academic High School, New Britain, Connecticut. Trips to the Emerson Laboratory and the Springfield Gas Company completed the program for the day. This meeting was

A HIGH SCHOOL BOY'S LETTER.

School Science and Mathematics,
5514 Cornell Avenue,
Chicago, Ill.

Gentlemen:

I recently subscribed to your publication, School Science and Mathematics; an act which I do not regret. I am a student in the Middleton, N. Y., High School, and as you can easily see, the publication is very valuable to me in my school work. Some time ago, one of my teachers said, in addressing my class, that scholars were queer folks, but I wish to add to that statement and say that some teachers are queer folks. What I'm hitting at is this:

Teachers who instruct in the very subjects in which you deal, take no periodical of any kind which deals with their work. They should take this publication just as much as the printer takes his, the doctor his, and the merchant his. Certainly the school could afford your reasonable fee. At any rate the mathematics teachers don't take a magazine of this sort, but I do, and I'm mighty glad I do. When some question is discussed in class, and I offer my reasons or suggestions, some one pops, "Where did you get your information?" Sure enough, I have a source of information.

Well! I've said enough, but I think that I have put this thought across, that your magazine is just what I have been looking for.

Wishing you future success, and with the season's best greetings, I am,

Most respectfully yours,

LEROY W. VAN KLEECK.

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held at the Technical High School, Springfield, Massachusetts, and was arranged for by Mr. Alfred R. Lincoln.

CORRESPONDING MEMBERSHIPS.

School and College Libraries can secure the reports of the Association in which full accounts of the proceedings at the meetings are published by taking out associate memberships. Apply to S. Walter Hoyt, Secretary 20 Stone Road, Belmont, Massachusetts.

BOOKS RECEIVED.

Educational Value of Certain After-School Materials and Activities in Science, by George Meister, Teachers' College, Columbia University. 175 pages. 15×22.5 cm. Paper. 1921.

Civic Science in a Community, by George W. Hunter, Gonx College, and Walter H. Whitman, Normal School, Salem, Mass. 430 pages. 14×23 cm. Cloth. 1922. American Book Company, Chicago.

An Introduction to Electrodynamics, by Leigh Page, Yale University. Pages vi+134. 15×20.5 cm. Cloth. 1922. $2.00. Ginn & Company, Chicago.

Gardening, by A. B. Stout, New York Botanical Garden, pages xvi+354. 13.5×18.5 cm. Cloth. 1922. $1.60. World Book Company, Yonkers-on-the-Hudson, New York, N. Y.

The Teaching of General Science, by W. L. Eikenberry, University of Kansas. Pages xiii+169. 13×20 cm. Cloth. 1922. $2.00+postage. The University of Chicago Press, Chicago.

The Earth and Its Life, by A. Waddingham Seers. 208 pages. 13×19 cms. Cloth. 1922. $1.20. World Book Company, Yonkers, N. Y.

An Elementary Manual of Physiology, by Russell Burton-Opitz, Teachers College, Columbia University. 14×20.5 cms. Cloth. 1922 $2.50. W. B. Saunders Co., Philadelphia.

Biology, by Charles Garmet, Stuyvesant High School, New York City. 112 pages. 15×22.5 cms. Paper. 1922. Globe Book Co., New York City

How to Study, by Fernando Sanford, Leland-Stanford University. Pages vi×56, 13×19 cms. Paper. 1922. The Macmillan Co., New York.

Laboratory Manual of General Science, by Lewis Elhuff, George Westinghouse High School, Pittsburgh, Pa. Pages viii×93, 13×19 cms. Cloth. 1921. D. C. Heath & Co.

Dangers and Chemistry of Fire for Primary Schools, by Clarence Maris. 78 pages. 18×23.5 cms. 1921. F. J. Heer Printing Co., Columbus, Ohio.

Practical Business Arithmetic, by Helen J. Kiggen, High School of Practical Arts, Boston. Pages xi+404. 13×19 cm. Cloth, 1922. The Macmillan Company, New York.

Elements of the Differential and Integral Calculus, with applications, by William S. Hall, LaFayette College, Easton, Pa. Pages xiii+250, 15×22 cm. Cloth. 1922. D. Van Nostrand Company, New York.

Calculus and Graphs, by L. M. Passano ,Massachusetts Institute of Technology. Pages viii+167, 13×19.5 cm. Cloth. 1922. The Macmillan Company, New York.

The Teaching of General Science by W. L. Eikenberry, University of Kansas. Pages xiii+169, 13×19.5 cm. Cloth, 1922. $2.10 postpaid. The University of Chicago Press, Chicago.

Annual Report of the General Education Board for 1920-21. Pages xi+129, 13.5×20 cm. Paper. General Education Board, 61 Broadway, New York.

REVISED LIST OF MEMBERS, EDUCATIONAL PRESS ASSOCIATION OF AMERICA, 1922

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Texas School Journal, Dallas	H. T. Musselman
Utah Educational Review, Salt Lake City	L. E. Cowles
Wisconsin Journal of Education, Madison	W. N. Parker

Laboratory Directions for Elementary Botany, by James B. Pollock, University of Michigan. 102 pages, 15×23 cm. Paper. George Wahr, Ann Arbor, Mich.

The Reorganization of Mathematics in Secondary Education. Bulletin No. 32, U. S. Department of the Interior, Bureau of Education. Pages vi+73, 15×23 cm. Paper. Government Printing Office, Washington, D. C.

BOOK REVIEW.

Elementary Principles of Chemistry, by Raymond B. Brownlee, Robert W. Fuller, William J. Hancock, Michael D. Sohon and Jesse E. Whitsit, all of New York City. New revised edition IX plus 580 plus 17. 27 mm.x14cm.x18.5cm. Profusely illustrated, cloth 1921. Allyn and Bacon.

This is an excellent revision of an excellent high school text. Among the new departures in the book we may note the inclusion of a chapter on colloid chemistry, one on gaseous and liquid fuels, the introduction of the idea of atomic number into the chapter on the periodic law, the retention of the "nascent state" hypothesis and the use of 22.2 liters as molal volume. The influence of the great war is felt in many places in the revised text, but not in a belligerent way. F. B. W.

Gardening, by A. B. Stout, New York Botanical Garden, pages xvi+134. 13.5×18.5 cm. Cloth, 1922. $1.60. World Book Company, Yonkers-on-the-Hudson, New York, N. Y.

This splendid book combined the theory and practice of gardening. It is as near complete as a text of this kind can be. The facts stated therein are scientifically accurate, and it can be used in all sections of the country. The first part of the book deals with the fundamental relations between plants and their environment, and a discussion takes place with reference to the needs of garden plants, as the nature and the kind of food. With the directions given in the first part of the text, a person can follow out the directions given in the other chapters to the actual growing of good crops. A discussion is given on the general principles connected with up-to-date gardening, such as the care of tools, the planting of the garden, and the elimination of bugs and weeds. The author has a knowledge of authority on this subject. being one of the foremost plant breeders in this country. The book is primarily designed for junior high school grades. Each chapter is followed by questions that naturally arise from the discussion of the subjects in that chapter. Major paragraphs begin with bold faced type, which indicates the discussion that will take place. It is printed in ten point type on paper that is good but not too glossy. The mechanical work of the book is of the best. It is filled with finely selected drawings in half tones that are to the point. Its splendid index is at the rear of the book. It is a book that is well worth the careful study of all school officials who intend to introduce the subject into their curriculum.

C. H. S.

Educational Value of Certain After School Materials and Activities in Science, by George Meister, Teachers College, Columbia University. 175 pages. 15×22.5 cm. Paper. 1921.

This book is the result of some investigations made by the author when preparing his thesis for the doctor's degree at Columbia University; he has investigated certain educational ideas that have existed for some

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

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time among all, apart from those that take place in the school room. These activities are very vital in shaping the life of the individual. We are determining that that which the pupil does outside of the school room has more to do with his after life than that which he does for himself in the school room. The idea of home study, play, reading, and nutrition are very important factors in its development. The author goes into a study of these functions which surround the pupil, and is partly a summary of results which are very valuable. Anyone wanting to be keen and alive to the proper development of a person, should possess a copy of this book and read and study it thoroughly.

C. H. S.

An Introduction to Electrodynamics, Leigh Page, Yale University. Page vi+134. 15×20.5 cm. Cloth. 1922. $2.00. Ginn & Company Chicago.

The fundamental purpose of this book is to present a logical development of the electromagnetic theory founded upon the principle of relativity. It has been the accepted theory up to the present time at least, to base electrodynamic equations on the data furnished by Ampére and Faraday. The theory is presented by the author, and the development of the electromagnetic equations is extremely interesting. The book is divided into eight chapters, chapter one giving the vital principles of the theory of relativity. Chapter two discusses the equations of a point charge, while chapter three discusses simultaneous field of a moving charge. Chapter four is devoted to the dynamical equation of the electron, and chapter five discusses the equations of the electromagnetic field. Chapter six is devoted to radiation. Chapter seven discusses electromagnetic fields in material media. The mathematics, as far as typographical work is concerned, is splendid. It is one of the best pieces of mathematical type setting that the writer has ever seen. The cuts are new and clear. The mechanical work of the book is of the highest class.

C. H. S.

Civic Science in a Community, by George W. Hunter, Gonx College, and *Walter H. Whitman,* Normal School, Salem, Mass. 430 pages. 14×23 cm. Cloth. 1922. American Book Company, Chicago.

This book by all odds is one of the best devoted to this phase of work that has come from any press. The author gets right next to the heart of the reader, and the young person cannot help but be interested in the content of the text. It is wonderful the number of phases of the subject that authors have touched upon. They have dealt with materials, factors, and forces. Perhaps the keynote of the book is the different form of instruments which man is using for his own enjoyment and edification. And since the child is coming on up into mature life, they have put these influences into such an interesting descriptive manner, that he cannot help but become intently interested in the study of the book. The fundamental purpose of the book, as the authors say, is to round out some of the science information previously acquired by the pupil. There are an innumerable number of cuts scattered throughout the book which have been selected with much care. Mechanically, the book is splendidly made, printed in ten-point type, major paragraphs beginning with bold-faced type, and at the close of each chapter is a list of reference books to matters discussed in that chapter. There is a splendid table column index of eight pages. People considering an introduction of Civic Science into their course cannot do better than to adapt this book.

C. H. S.